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Civilian Radioactive Waste Management System
Management & Operating Contractor

Off-site Utilities Preliminary Assessment

B00000000-01717-5705-00091, Rev. 00

March 30, 1998

Prepared for:

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Under Contract Number
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Prepared by:

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1. INTRODUCTION

This technical document provides a preliminary assessment of the off-site electrical utility installations, water supply, and communications necessary to support the construction, operation, and development of the Yucca Mountain Project (YMP). The primary emphasis is on the electrical utility installations, with a secondary emphasis on water supply and communications.

1.1 INTERFACES

This technical document interfaces with:

- On-site electrical system
- Public electrical utilities
- On-site water facilities
- On-site communications

1.2 QUALITY ASSURANCE

This technical document is not subject to the *Quality Assurance Requirements and Description* (OCRWM DOE 1997). This determination is documented in a QAP-2-0 activity evaluation. This technical document has been completed in accordance with Nevada Site Administrative Line Procedure NAP-MG-012, *Development of MGDS Technical Documents not Subject to QARD Requirements* (CRWMS M&O 1995a). QA: None.

1.3 REPORT ORGANIZATION

Following this introduction, this technical document is divided into three sections:

- Section 2 assesses preliminary alternatives for supplying power to the YMP repository facilities.

- Section 3 identifies upgrades to the off-site surface water supply system needed to meet water requirements for the repository surface and subsurface facilities during construction and operation.

- Section 4 is a preliminary assessment of the communications system between the YMP site, government and offices, waste generators, and in-transit waste transporters.

References for each topic in Sections 2, 3, and 4 are included at the end of the relevant section. Appendix A is a list of acronyms and abbreviations. Appendices B through D contain supporting information for the electrical and water supply sections of the report.

2. ELECTRICAL SUPPLY

2.1 OBJECTIVE

This section provides a preliminary assessment of the electrical off-site utilities installations required to supply power to the Yucca Mountain Project (YMP) repository facilities.

2.2 SCOPE

Currently, the YMP receives power from the Nevada Test Site (NTS) electrical network. The NTS network transports electrical energy by means of two transmission lines, one owned and operated by the Nevada Power Company (NPC), the other by Valley Electric Association (VEA). Previous studies (Section 2.3) have indicated that the capability of the current transmission system to serve the YMP's needs may be limited. This technical report assesses the present transmission system and discusses future developments needed to meet the YMP repository requirements. Its scope includes:

- Performing a preliminary study of YMP electrical load demand based on the present design development.
- Reviewing previously published studies of possible methods of bringing electrical power to the YMP.
- Developing feasible alternatives to the present off-site utilities transmission system.
- Evaluating the alternatives in terms of power supply reliability, optimal design, and economic feasibility.
- Recommending the best concept for supplying power to the YMP.

Because of the preliminary nature of this technical document, the public utilities mentioned in this report (NPC and VEA) were not consulted; the alternatives presented in this report have been developed on the basis of previous studies.

2.3 BACKGROUND

Previous studies by various entities provided alternative concepts for high-voltage transmission systems to transport energy to the NTS from neighboring utilities, such as Nevada Power Company and Valley Electric Association. These studies (listed in Section 2.10.2) are briefly summarized below.

The *Transmission System Study* by Stanley Consultants (1985) recommends and summarizes the requirements for a transmission upgrade of the NTS to support the YMP.

The *Yucca Mountain Project 138 kV Power Flow Analysis* by Raytheon (1991) refers to previous studies and indicates the need for new transmission lines into the NTS.

The *Value Engineering Team Study Report: Power Distribution Systems* (VMI 1992) studies the NTS power system, but does not include YMP loads as part of its analysis.

Relocation of System Generators for Yucca Mountain Project (Raytheon 1994) determined that, if either power source (NPC or VEA) had an outage on the main line serving the NTS, the system would collapse. The YMP loads used in the study were less than the loads currently forecast.

The *Impact Study of the VEA 230 kV Power Line for the Yucca Mountain Project* (Raytheon 1995) discusses the impact of building a new 230-kilovolt (kV) line from the Mead Substation to the Pahrump Substation. This study concluded that the VEA power system then under consideration would not support 8 megawatts (MW) of load at the YMP under normal conditions by the years 1995 or 1996 unless the new 230-kV was completed.

In summary, these studies indicate that the total NTS load, including loads for the YMP, would exceed the firm capacity of the electrical transmission and distribution systems currently available at the NTS and in the surrounding area.

2.4 DESIGN REQUIREMENTS

Sources consulted for requirements for this preliminary assessment of the electrical supply for the YMP were the *Engineered Barrier Design Requirements Document* (OCRWM YMP 1994a), the *Repository Design Requirements Document* (OCRWM YMP 1994b), and the *Exploratory Studies Facility Design Requirements* (OCRWM YMP 1997). Exploratory Studies Facility design requirements are not in the scope of this technical document; however, they have been listed as a source for development of future criteria. The *Engineered Barrier Design Requirements Document* does not specifically address off-site utilities.

2.4.1 The electrical power system will be designed in accordance with DOE Order 6430.1A, Division 16, "Electrical" (DOE 1989); American National Standards Institute (ANSI) C2, *National Electrical Safety Code* (OCRWM YMP 1994b, Sections 3.7.3.2.B, 3.3.1.A, and 3.3.1.B).

2.4.2 Generally, power will be purchased from an available off-site utility company rather than be obtained from on-site generating stations (DOE 6430.1A, Section 1620-1; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.3 Electrical service quality and reliability will conform with IEEE 493 to ensure that they meet the load requirements (DOE 6430.1A, Section 1630-1.1; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.4 Where loads require a high degree of voltage and frequency stability, the available short circuit megavoltamperes (MVA) at the service connection and the stability of the supplying utility system will be considered to ensure adequate power quality (DOE 6430.1A, Section 1630-1.1; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.5 An overall power factor of not less than 85 percent will be achieved. When power-factor correction is required, the amount of correction will be coordinated with the billing tariff to prevent uneconomical overcorrection (DOE 6430.1A, Section 1630-1.2; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.6 Facilities designated by the cognizant DOE authority as critical will be served by two dedicated, redundant circuits. The two circuits will be physically separated and will be served from separate sources. Alternatively, rather than providing two separate services, a single service supplied from a loop-type transmission or distribution system with sectionalizing features may be used, providing the reliability of the single service proves adequate and conforms with IEEE 399 and IEEE 493 (DOE 6430.1A, Section 1630-1.3; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.7 Electrical circuits will be located in utility corridors established on master utility plans (DOE 6430.1A, Section 1630-1.4; OCRWM YMP 1994b, Sections 3.3.1.A and 3.3.1.B).

2.4.8 The repository segment interfaces with the commercial power grid at the MGDS main substations. The MGDS requires (OCRWM YMP 1994b, Section 3.2.3.4):

- 230-kV loop feed (TBV); based on Assumption 2.5.5.
- 36.7 MVA (TBV); based on preliminary electrical load demand in Section 2.6.
- 60 hertz ± (TBD) percent.
- Three-phase connections.

2.4.9 Lightning protection, including lightning arrestors, static wires, and grounding systems, shall be provided. Lightning protection shall be provided for all major building and surface facilities. A ground grid shall be provided around each surface facility and shall be tied to a single point ground system (OCRWM YMP 1994b, Section 3.7.3.1).

2.4.10 Electrical systems and components shall be selected, designed, and installed as required by 29 CFR 1910, Subpart S (OCRWM YMP 1994b, Section 3.3.6.11.A).

2.4.11 Protection against electrical hazards shall conform to the National Electrical Code (NFPA 70), the National Electrical Safety Code (ANSI Standard C2), and, for underground applications, 30 CFR 57, Subpart K (OCRWM YMP 1994b, Section 3.3.6.11.C).

2.4.12 The surface power system shall be routed in compliance with the results of the archaeological surveys performed as part of Stipulation 4 in the Programmatic Agreement Between the United States Department of Energy and the Advisory Council on Historic Preservation (December 1988) (OCRWM YMP 1994b, Section 3.4.5.2.1.AB).

2.5 ASSUMPTIONS

No assumptions that applied to this technical report were found in the *Controlled Design Assumptions Document* (CRWMS M&O 1997b). Assumptions needed for this report are as follows:

2.5.1 Two 7.62-m tunnel boring machines (TBMs) may be used to accelerate the construction of main drifts.

2.5.2 Two 5.5-m TBMs may be required for a more aggressive waste delivery schedule (CRWMS M&O 1997a).

2.5.3 Surface electrical loads remain relatively constant during the emplacement period.

2.5.4 Firm capacity is defined as the amount of power that can be always available even under abnormal conditions.

2.5.5 A loop-type system with firm capacity will be required to meet requirement 2.4.6 and to comply with the present agreement between the public utilities. Firm capacity is defined in Assumption 2.5.4.

2.6 ELECTRICAL LOAD DEMAND

The subsurface and surface loads were taken from currently available sources, such as the *Subsurface Construction and Development Analysis* (CRWMS M&O 1997a) and *Site Electrical System Technical Report* (CRWMS M&O 1998). The load demand study was developed in accordance with the high-density waste emplacement scenario and the equipment loads required throughout the phases of the life of the repository.

The repository will be constructed and operated in the following overlapping phases:

- Construction
- Development
- Emplacement
- Caretaker
- Closure

The electrical power demand for the repository will increase very rapidly during the first 5 years of construction. The magnitude of the subsurface loads is estimated to be 25.6 MVA by the fourth year of construction, when the load will peak as a result of the construction phase overlapping with the first year of development. When the construction phase is completed in year 5, the electrical load will fall to approximately 22.7 MVA, remaining relatively constant at that level through the development and emplacement phases of the project. At the same time that the subsurface loads begin to increase, the surface loads will increase to a level of 13.7 MVA; it was assumed (Section 2.5.3) that surface loads will also remain relatively constant through the end of the emplacement phase.

Table 1 shows the preliminary subsurface electrical load for the fourth year of construction, when the subsurface load is anticipated to be peaking. Table 2 shows the anticipated typical subsurface electrical load demand through the emplacement and development phases.

Table 1. Preliminary Subsurface Electrical Load for Construction - Year 4

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CONSTRUCTION - YEAR # 4

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connected Load (hp)	Connected Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (7.6 m) No 1	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (7.6 m) No 3	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (5.5 m) No 2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	TBM (5.5 m) No 4	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Header No 1 (includ. Bendicar)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Header No 2 (includ. Bendicar)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Down Hole Shaft Reamer	1000.00			0.90	900.00	0.94	0.89	802.53			802.53	
	Drill Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	East Main Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	Exhaust Main Drifit Conveyor	600.00			0.90	540.00	0.94	0.88	486.99			486.99	
	Overland Conveyor with Stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Rail Transportation (6x120 hp)		720.00						720.00			720.00	
	Lighting		1270.00						1270.00			1270.00	
	Underground Facilities		800.00						800.00			800.00	
	Development Shaft hoist			250.00									
	Emplacement Shaft hoist			250.00									
	Emplacement Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Development Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Auxiliary Construction Fans (3x250 hp)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Auxiliary Construction Fans (3x150 hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Dust Collectors (4x150 hp)	600.00			0.90	540.00	0.94	0.88	486.99			486.99	
	Water Pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	
	Welders		60.00						60.00			60.00	
	Batch Plant	200.00			0.95	190.00	0.93	0.89	171.25			171.25	
	South Portal Facilities		3000.00						3000.00			3000.00	

Total Connected Load (hp) : 25633.00
Total Connected Load (kVA) : 5850.00
Total Standby Load (hp) : 500.00
Total Demand Load(kVA): 25646.97
Total Actual Load (kVA):
Total Peak Load (kVA): 25646.97

Table 2. Preliminary Subsurface Electrical Load for Development and Emplacement

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: EMPLACEMENT-YEARS 6 thru 28

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connected Load (hp)	Connected Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (5.5) No.1	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	TBM (5.5) No.2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Headers No.1 (incl Bendicar)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Headers No.2 (incl Bendicar)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Ventilation Raise Boring Machine	400.00			0.90	360.00	0.93	0.87	331.92			331.92	
	Drill, Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	Rail Transportation. Waste Packages		2000.00						2000.00			2000.00	Assuming 1HP=1kVA
	Rail Transportation (3x120hp)		360.00						360.00			360.00	Assuming 1HP=1kVA
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	East Main Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	Overland Conveyor with Stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Underground Facilities		800.00						800.00			800.00	
	Lighting		1270.00						1270.00			1270.00	
	Emplacement Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Emplacement Shaft Booster Fans (2x1250)	2500.00			0.90	2250.00	0.95	0.90	1963.16			1963.16	
	Development Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Aux Development Fans (2@150hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Fixed HEPA Filters (2x150hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Mobile HEPA Filters & Chillers			1000.00	0.90	900.00	0.94	0.89					
	Batch Plant		200.00						200.00			200.00	
	South Portal Facilities		3000.00						3000.00			3000.00	
	Dust Collectors (2x150hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Welders		60.00						60.00			60.00	
	Water pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	

Total Connected Load (hp) : 19903.00
Total Connected Load (kVA) : 7690.00
Total Standby Load (hp) : 1000.00
Total Demand Load(kVA): 22681.36
Total Actual Load (kVA):
Total Peak Load (kVA): 22681.36

Surface load requirements must be added to the subsurface loads shown in Tables 1 and 2 to ensure that adequate power is available for the entire YMP. These load values are taken from the *Site Electrical System Technical Report* (CRWMS M&O 1998).

Figure 1 is a graph indicating load demand over time and phases for operation of the repository. It includes a composite curve consisting of surface and subsurface loads throughout the life of the repository. The estimated peak load demand for the repository overall is 36.7 MVA by the fifth year. Appendix B includes additional tables developing the load for each year of construction and the caretaker phase.

2.7 ASSESSMENT

As indicated in the scope of work, this preliminary assessment is based on previous studies prepared to evaluate the NTS electrical system and the impact of the YMP upon it. These studies were conducted at different times within the last 12 years. The information in this preliminary assessment will be confirmed and updated, in the next stage of engineering development, with analyses, load studies, and current data from public utilities.

2.7.1 Power Supply by the NTS

Previous studies, as detailed below, clearly indicate that the NTS electrical system does not have the capacity to supply the currently estimated YMP repository loads. The NTS system is supplying the Exploratory Studies Facility (ESF) via the Canyon Substation; however, this is possible only because with the current nuclear testing moratorium in effect, the other loads on the NTS system are reduced, allowing power to be distributed to the YMP.

The YMP repository loads are sufficiently large to require that, at a minimum, both utility companies serving the NTS improve their transmission capabilities from the Las Vegas area to the NTS. If the NTS system is then used to serve the YMP, changes will be required at Canyon Substation, and the 138-kV line from Mercury Switching Station to Jackass Flats Substation may be upgraded. These modifications are in addition to those required by the utility companies.

This study considers the alternatives that might be implemented to provide a reliable source of power for the YMP. The study considers the effects of on-site construction required to serve the YMP from the NTS system, as well as whether it may be more desirable if the YMP is served directly by the utility companies themselves. The significant difference between these two possibilities is that, if the YMP is served directly by the utility companies, the need to make any significant NTS system changes is minimized and conceivably eliminated. In addition, construction will be allowed to start at the earliest possible time without consideration of the NTS system and its reliability.

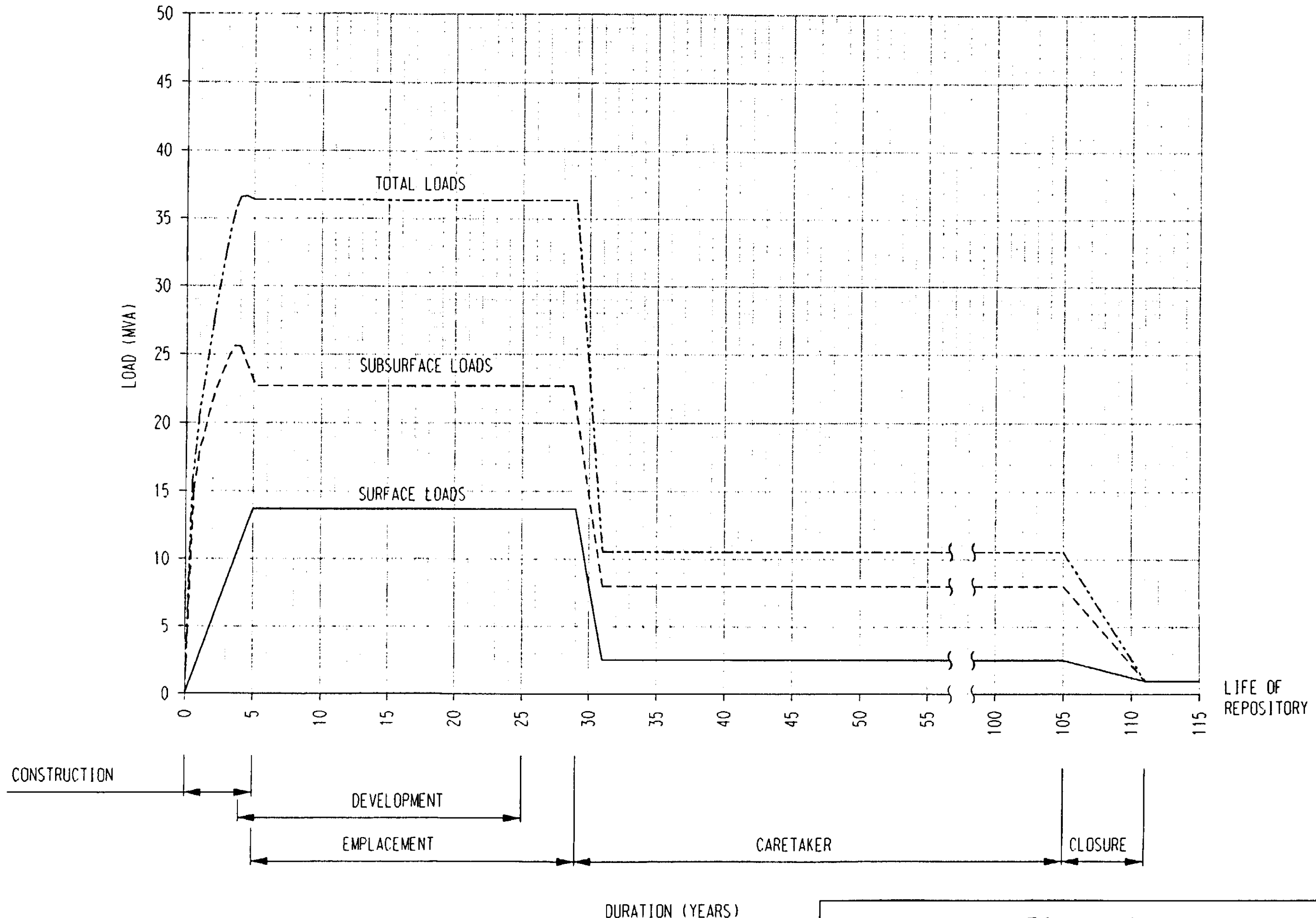

Figure 1
PRELIMINARY ESTIMATED
ELECTRICAL LOADS

2.7.2 Power Supply by Local Utilities

The most viable and cost-effective means of assuring that adequate power is available at the YMP is to have the electric utilities, NPC and VEA, improve their transmission systems to the area and to provide a new substation at the YMP to serve the repository. The new construction would serve the YMP, allowing the repository to be built. The existing lines and substations for the NTS would remain in place. At the same time, the improved transmission system will provide the increased capacity to expand the NTS in the future, should it become necessary, will improve the reliability of the utility companies' systems, and will most likely allow them to serve increased off-site loads in the area in the future.

2.7.3 Load Flow Analysis

The VEA and NPC lines serving the NTS form a high-voltage loop (Stanley 1985). Both of these lines extend from the Las Vegas area, where the power system is an integrated system with ties between all major substations, and terminate in the Jackass Flats Substation at the NTS. Both of these lines serve off-site loads at various areas between the Las Vegas and the NTS location. The off-site loads, particularly those served by VEA, are the cause of the power limitations to the NTS, since both the VEA and the NPC lines provide backup to each other under emergency conditions, when a portion of either is out of service. The NPC line has a very small capacity, and when called upon to serve the more substantial VEA loads under emergency conditions, one of two situations arise:

- If the total load being served is in excess of the line capacity, it is automatically removed from service. In an attempt to negate this possibility, load-shedding techniques may be employed.

- Alternatively, if the loads are not in excess of the line capacity, voltages may be reduced to as much as 90 percent of their normal level. If this condition persists over a period of time, NTS loads will inevitably be affected.

A review of *Transmission Line System Study* (Stanley 1985) indicates that the service to the NTS will be marginal even under normal conditions based on a 90 percent power factor for NTS loads. Furthermore, voltages on the NTS are below the minimum acceptable voltage of 95 percent when the NPC line supplies 39 MW to the NTS and no power flow is provided to the VEA (the Jackass Flats Substation to Lathrop Wells Substation line is open).

The *Yucca Mountain Project 138 kV Power Flow Analysis* (Raytheon 1991) states that for the 1991 summer peak (36 MW), under load conditions with the existing uncorrected power factor and no YMP loads, all NTS 138-kV bus voltages are below the minimum acceptable voltage of 95 percent; one bus is below 90 percent. If an outage occurred on the Jackass Flats to Lathrop Wells line, NTS bus voltage would drop even more.

Both of these studies support the conclusion that the presently installed NPC line cannot support growth of the NTS load beyond the 36 to 39 MW range without jeopardizing the system.

By contrast, when VEA is called upon to serve NPC loads because of an outage of a portion of NPC's line, the situation is less critical at this time, because the VEA line has much greater capacity. However, the situation will become critical with time, because the VEA off-site loads are increasing each year, as noted in the *Impact Study of the VEA 230 kV Power Line for the Yucca Mountain Project* (Raytheon 1995). The report, which was prepared specifically to assess the capability of the VEA line serving the NTS system, indicates that the existing VEA line can provide a maximum of 114 MW to the area. This limit can be increased to 125 MW with the addition of capacitors. The report also includes a projection (to the year 2035) of the growth of off-site loads being served by the line, indicating that sometime between 2010 and 2015, the VEA line will not adequately serve as backup to the NPC line for the NTS, even with the addition of capacitors at Valley Substation. Furthermore, the report considers a YMP load of 2.5 MW, which is far less than is estimated at this time.

Raytheon's study, *Relocation of System Generators for Yucca Mountain Project* (1994), examined the existing system, which at that time did not have the VEA 230-kV line from Amargosa to Pahrump in service. The report concluded that the total load, including 25 MW for the YMP, could operate successfully and maintain reasonable voltage control with an outage occurring at three of the four locations considered in the study, unless the outage occurred at Amargosa Substation. The study determined, however, that the utility company's line that remained in service to feed the NTS would be thermally overloaded, an unacceptable situation.

The final transmission system should be robust enough to supply the YMP and NTS loads under any off-site electrical system upset conditions resulting from the loss of any VEA or NPC source of power without requiring additional on-site generation. On-site generation should be used only to support critical YMP loads during a total loss of power. Two clearly potential upset conditions are as follows:

- Loss of the power source at Amargosa Substation or Mead Substation, which would hamper VEA's ability to serve the YMP or NTS. Such a loss would result in a sudden increase in the load on the NPC system if it provides backup to VEA off-site loads.

- Loss of the power source for the NPC lines would result in a similar increase on the VEA load. However, this situation might not be as severe as a loss in the VEA power source, because NPC off-site loads are much smaller.

Other upset conditions may need to be studied during planning for the permanent system. Presently anticipated load requirements indicate that some of the required power can be supplied to the YMP with the addition of capacitors, as demonstrated by Raytheon (1995). However, by the year 2005, even with capacitors the capacity will be insufficient for the projected load growth.

An NPC outage would overload the VEA line between Pahrump Substation and Lathrop Wells Substation; conversely, on-site power generators can be installed to support the voltage at the NTS (Raytheon 1994). However, under conditions of line overloading, the utilities would be forced to drop the load, pulling the system down.

Further analysis of the present system, including the anticipated YMP loads as presented herein and several potential line outage scenarios, is warranted. The analysis should include the load flow with the system capacity improvements as suggested in this technical document. Suggested recommendations (see Section 2.9) are that VEA upgrade its line from Pahrump Substation to Lathrop Wells Substation to 230 kV, and that NPC increase its capacity from the source to Mercury Switching Station.

NPC may increase its capacity by adding a 138-kV line or a 230-kV line from Pecos Substation to Mercury Switching Station or by increasing the voltage on the existing line from 138 kV to 230 kV. The NPC may also build a line to interconnect with Sierra Pacific Power Company (Stanley 1985).

These options require further analysis of cost considerations, load flow and, most importantly, reliability. With further development and planning, the improvement implemented to serve the YMP reliably will also serve both utilities by increasing their reliability throughout the region well into the next century.

With the proper switching and protective schemes and line enhancements (to be designed in a future analysis), NPC, VEA, and perhaps a third utility would be able to support themselves in the event of a line or equipment failure, to their own benefit as well as that of the YMP and NTS.

It is also possible that the YMP could be served at 230 kV instead of at 138 kV, depending on the transmission voltage selected by the utilities and their preferred integration method. NPC may increase its voltage to 230 kV as far as Jackass Flats Substation; in this case, assuming VEA does the same to Lathrop Wells Substation, it would be more desirable to equip the YMP with 230-kV power lines.

Life-cycle cost techniques may be considered; however, given the duration and critical nature of the project, they should not be given the same emphasis as reliability analysis. On-site power generation should be considered only for required emergency service when a major event occurs, not to support a weak utility line.

2.7.4 On-site Utility Corridors

The NTS Master Electrical Utility Map (BN NTS undated) indicates that, subject to physical site inspection, examinations of existing line structure, and available space, a loop-type system can be built from Lathrop Wells Substation to Canyon Substation and Jackass Flats Substation on existing right-of-way corridors.

2.7.5 Transmission System Requirements And Alternatives

Presently, VEA operates a 138-kV line in parallel with a 230-kV line from Amargosa Substation to Pahrump Substation and a single 138-kV line from Pahrump Substation to Jackass Flats Substation. As noted in Raytheon's study (1995), the maximum capability of these lines is 114 MW without capacitors at Valley Substation, and 125 MW if the capacitors are added.

These limits are based upon maintaining suitable voltage regulation rather than the thermal loading of the conductors.

Similarly, 39 MW is available at the Mercury Switching Station from the NPC line based upon maintaining suitable voltage regulation, as noted by Stanley (1985).

The NPC line cannot, therefore, back up the VEA lines at this time. If there is a failure in the VEA lines that results in a load flow in excess of 39 MW through Mercury Switching Station, low voltages will occur in the NTS system. If there is a failure in the NPC line, the VEA line will not adequately support the NTS after approximately the year 2000, if the off-site loads on the VEA system increase as expected. It is apparent that, if the NPC and VEA systems are to be able to back each other up, thereby providing reliable power to the NTS and YMP, both companies must improve their transmission capability in the area. Table 3 shows the current and projected electrical loads for the lines serving the NTS and YMP. Note that there may be inaccuracies in Table 3 because of two related reasons, as follows:

- As noted on the table, the anticipated growth in the VEA off-site loads has been assumed to be 3 percent per year. Raytheon (1995) indicates that growth should be anticipated in the future and that recent past growth has reached 7 percent in some years. It is highly unlikely that a rate of 7 percent per year will occur over a 35- to 40-year period. The value used in Table 3 is more realistic, but it is nevertheless an estimate.

- Raytheon (1995) could not provide a location for the growth areas. Therefore, the 114 MW maximum loading for this line (without capacitors) may vary to some extent, depending upon the actual location where load growth occurs. If the growth area is near the VEA source, the capacity of the line at NTS may be slightly greater, providing that the thermal limit of the conductor is not exceeded. Similarly, if NPC backs up this load at such a location, its lines may need to be more substantial to maintain suitable voltage regulation at NTS.

While neither of the above items is expected to introduce significant errors, they should both be investigated further before performing further load flow studies.

Table 3. Electrical Loads for Selected Years between 1997 and 2035
(All loads are in MW)

Item No.	Year: Load Served:	1997	2005	2010	2015	2020	2025	2030	2035
1	**YMP** Loads[1]	6	18	32	32	32	32	32	21
2	Existing **NTS** Loads[2]	28	28	28	28	28	28	28	28
3	Total **NTS** and **YMP** Loads, (Item 1 plus item 2)	34	46	60	60	60	60	60	49
4	**NPC** Off-Site Loads[2]	11	11	11	11	11	11	11	11
5	**VEA** Off-Site Loads[3]	64	81	94	109	126	146	170	197
6	Total Load to Be Provided By the Remaining Utility Company Upon Loss of the Other Utility Company's Source (Sum of items 3, 4 & 5)	109	138	165	180	197	217	241	257
7	**VEA** Present Capacity W/O Capacitors[3]	114	114	114	114	114	114	114	114
8	Required Additional Capacity - **VEA** System (Item 6 less item 7)	0	24	51	66	83	103	127	143
9	**VEA** Present Capacity With Capacitors[3]	125	125	125	125	125	125	125	125
10	Required Additional Capacity - **VEA** System (Item 6 less item 9)	0	13	40	55	72	92	116	132
11	**NPC** Present Capacity[4]	49	49	49	49	49	49	49	49
12	Required Additional Capacity - **NPC** System (Item 6 less 11)	60	89	116	131	148	168	192	208

[1]MW values are obtained from MVA values in Figure 1, applying a 90 percent power factor.
[2]Estimated loads for the NTS and NPC off-site loads are taken from Raytheon (1995). This document notes that both loads are subject to very little growth.
[3]Projected growths for the VEA off-site loads is based upon the data for year 1997 as tabulated in the Raytheon (1995). Growth estimates for off-site load in subsequent years is based upon an annual growth rate of 3 percent are extrapolated from the same data.
[4]NPC line capacities are derived from data contained in Stanley (1985) and Raytheon (1991).

Before construction begins, load flow studies must be developed to finalize the required system improvements for each of the suppliers, NPC and VEA. NPC and VEA must then design their transmission system to conform with the results of these load flow studies. They must determine whether or not they will continue to provide backup power to each other, as is assumed in Table 3. If they determine that backing one another up is not feasible, each of the two companies must modify its transmission capability to serve the total load at the NTS and YMP. In this case, automatic load shedding must be included at Mercury Switching Station and Jackass Flats Substation to remove the failing system lines from the buses.

If either of the two utility companies determine that it may be best to interconnect their system in the NTS area with a third company, such as Sierra Pacific Power Company (SPC), the load flow studies must include this information so as to verify that two independent sources of power are available to serve the NTS and YMP.

In Table 3, load growth is projected through 2035. There are no records of load growth projections by VEA, NTS, or NPC beyond 1997; the information in Table 3 is estimated using projections made by Raytheon (1995). These utility loads will be increasing, especially VEA's loads. The SPC load may also increase in the region. YMP loads will not start decreasing until about 29 years into the project.

The system capacity improvements may be achieved at 138 kV. However, because of distances involved, line losses, and trends in the region, it is more suitable to increase system capacity using 230-kV lines. The 230-kV voltage has been introduced as close as Pahrump Substation, approximately 50 miles from the site. NPC has constructed a 230-kV line from its Pecos Substation to the North West Switching Station, but is operating at 138 kV until it needs to increase the capacity to 230 kV. This line is about 90 miles from the YMP. Sierra Pacific has 230 kV at its Anaconda Substation, which is approximately 160 miles from the YMP site.

Constructing or upgrading lines from two of these three utilities will achieve the firm capacity desired. Constructing lines from all three utilities will benefit the three utilities as well as the YMP and the NTS.

2.7.6 On-site Service Voltage

Two possible voltages are available for the size loads anticipated: 138 kV and 230 kV. Both the 138-kV and 230-kV levels are viable. Selection of the voltage will be based primarily on the voltage of the utilities serving the site and results of load flow studies. If the site can be served with the firm capacity of approximately 50 MVA at 138 kV, then the YMP equipment will be rated for the 138-kV level.

If the utilities serve the site at 230 kV initially, the primary equipment will be rated for 230 kV. The transformer costs are the same or could even be less expensive at 230 kV. The primary circuit switchers, or circuit breakers with associated disconnect switches, will be more expensive at 230 kV. However, this cost can be offset by eliminating the need for an autotransformer to reduce 230 kV to 138 kV, which incurs energy losses. Reliability will also be greater without the autotransformer in the YMP system.

2.7.7 Transmission Switchyards at the YMP Site

Under the assumption that a loop-type transmission system will be required for the YMP (Section 2.5.5), it is anticipated that two switchyards will be built, the first one adjacent to the main substation near the North Portal, and the second one adjacent to the substation at the South

Portal. These switchyards will be the interface with the MGDS site electrical system described in the *Site Electrical System Technical Report* (CRWMS M&O 1998). One of the two transmission lines serving the YMP will terminate in the North Portal switchyard, the other in the South Portal switchyard. A line will be constructed to tie the two switchyards. This tie line will have a circuit breaker on each end to facilitate removal of any portion of the high-voltage system for maintenance. A preliminary scheme of the switchyards is depicted in Figure 2.

It is anticipated that the utility company will own and operate the transmission system to the point of the interconnect. The YMP should have control of the switchyards, the main transformer circuit breakers, and all medium voltage circuit breakers downstream of the step-down transformers.

2.8 SYSTEM IMPROVEMENT ALTERNATIVES

The final system serving the YMP could be configured on the basis of several alternatives, as described below. The existing transmission system at the YMP is shown in Figure 3. Final selection of the alternatives is subject to review and further study. Only Alternative D, as described in Section 2.8.4 and discussed in Section 2.8.8, is able to stand alone. The remaining alternatives need to be considered in combination with one another in various configurations to yield the firm capacity required. A brief description of each alternative follows:

2.8.1 Alternative A

Build a 230-kV line from Pahrump Substation to Lathrop Wells Substation. Build a 230-kV line from Lathrop Wells Substation to the YMP. From the YMP, connect loop to Canyon Substation at 230 kV, using an autotransformer at Canyon. See Figure 4.

2.8.2 Alternative B

Build a new 230-kV line from North West Switching Station (Near Las Vegas) to Mercury Switching Station. Install an autotransformer at Mercury Substation to connect the new 230-kV transmission line to the existing 138-kV NTS system. Upgrade the 138-kV line conductor from Mercury Switching Station to Jackass Flats Substation to Canyon Substation. Build a 138-kV line from Canyon Substation to the YMP and from the YMP to Lathrop Wells Substation. Upgrade line voltage to 230 kV from Pecos Substation to North West Switching Station. See Figure 5.

2.8.3 Alternative C

Build a 230-kV line from Pahrump Substation to Lathrop Wells Substation, as in Alternative A. Build a 138-kV line from the YMP to Lathrop Wells Substation. A 138-kV line will be constructed from the YMP to Canyon Substation. Install an autotransformer at Lathrop Wells Substation to connect the 230-kV system to the 138-kV system. See Figure 6.

2.8.4 Alternative D

Build a 230-kV line from North West Switching Station to Jackass Flats Substation; it is anticipated that a new 230-kV switchyard adjacent to Jackass Flats Substation will be constructed. Build a 230-kV line from Pahrump Substation to Lathrop Wells Substation. Build a 230-kV loop from Lathrop Wells Substation to the YMP, and from the YMP to Jackass Flats Substation. Upgrade line voltage to 230 kV from Pecos Substation to North West Switching Station. This alternative will be able to serve the YMP directly from public utilities, entirely independently of the NTS. See Figure 7.

2.8.5 Alternative E

Build a 230-kV line to Sierra Pacific Power Company. This line could be built from Anaconda to Mercury Switching Station by NPC, or to Lathrop Wells Substation by VEA, as shown in Figure 8. Build a 230-kV loop from Lathrop Wells Substation to the YMP, and from the YMP to Canyon Substation. Install an autotransformer at Canyon Substation to connect the 230-kV system to the 138-kV system.

2.8.6 Alternative F

Alternative F is the same as Alternative B, except the new line from North West Switching Station to Mercury Switching Station is 138 kV (no figure is provided).

2.8.7 Alternative G

Build a 230-kV line from Anaconda to Lathrop Wells Substation to Pahrump Substation. Build a 230-kV line from North West Switching Station to Jackass Flats Substation. Build a 230-kV loop from Lathrop Wells Substation to the YMP, and from the YMP to Jackass Flats Substation. Upgrade the line voltage to 230 kV from Pecos Substation to North West Switching Station. This is a combination of Alternatives D and E. See Figure 9.

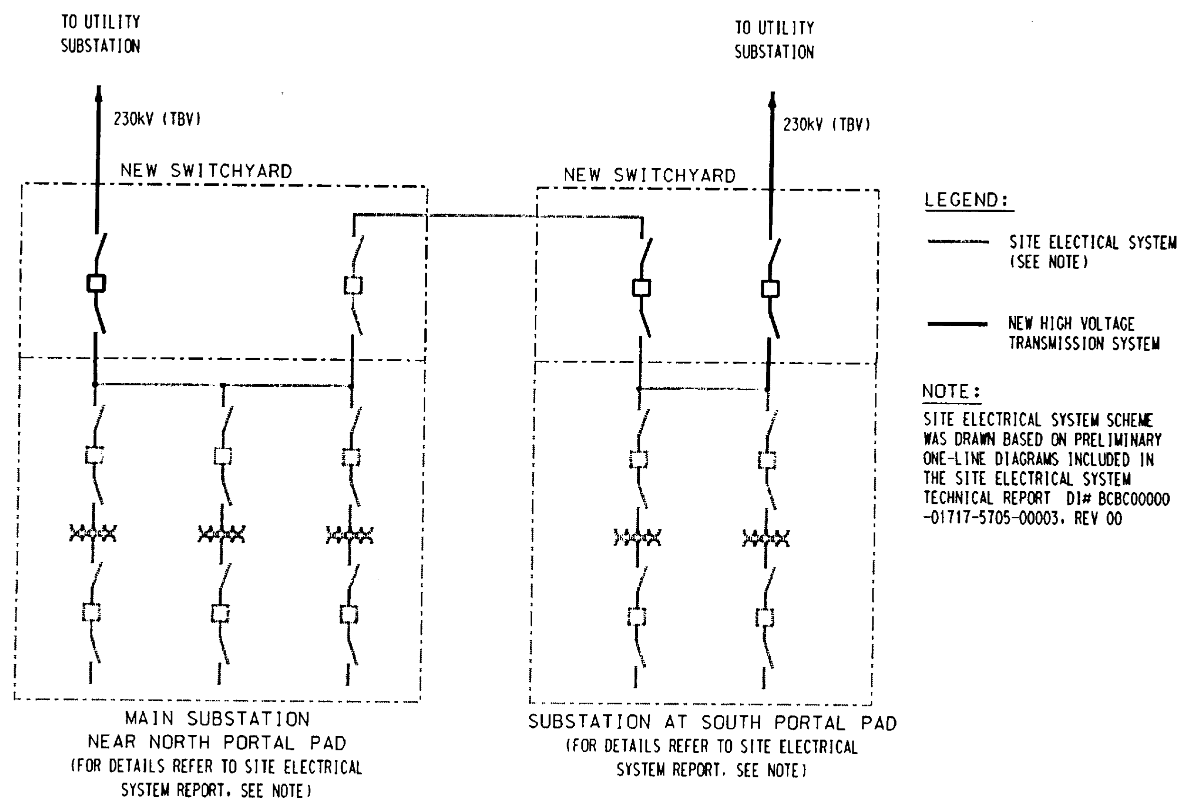

Figure 2
TRANSMISSION SWITCHYARD
AT YMP SITE

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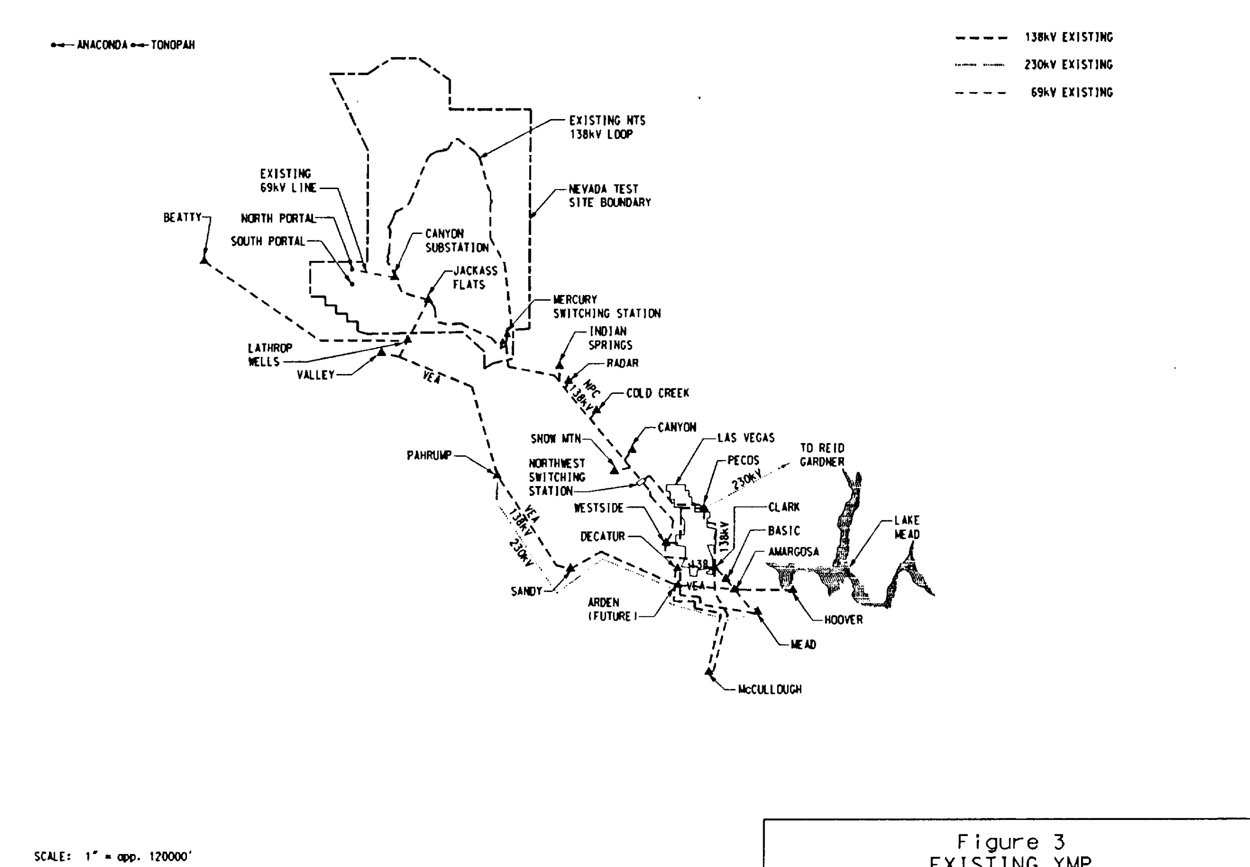

Figure 3
EXISTING YMP
TRANSMISSION SYSTEM

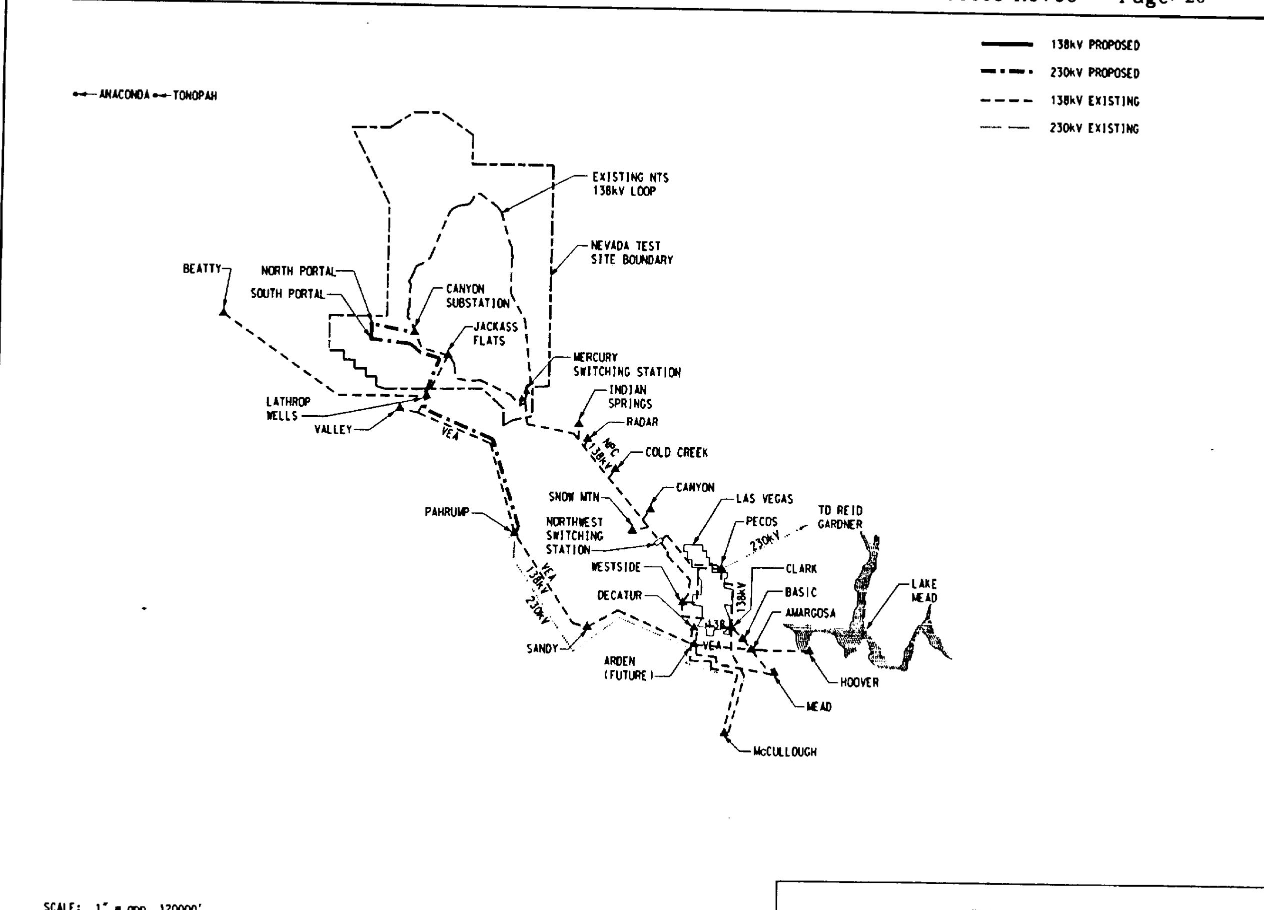

Figure 4
ALTERNATIVE A

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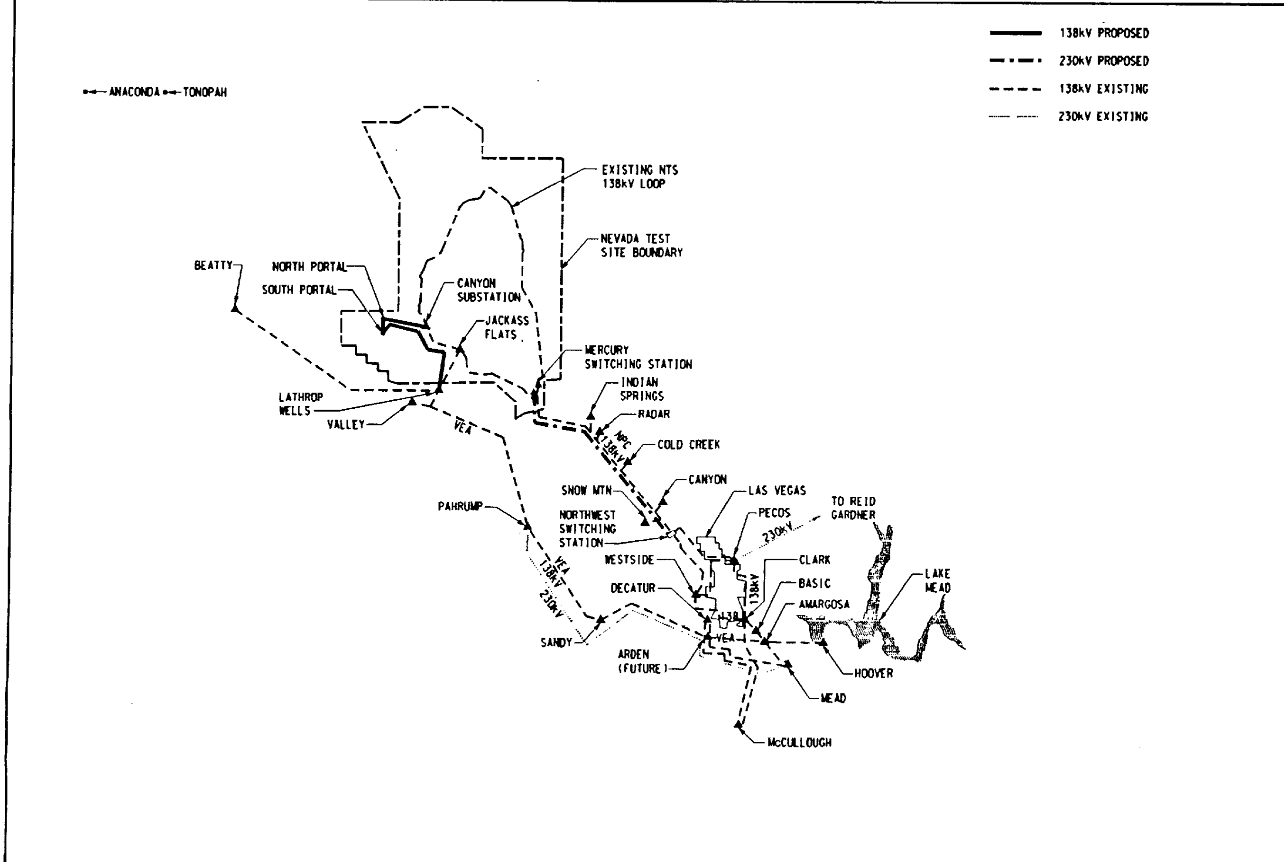

Figure 5
ALTERNATIVE B

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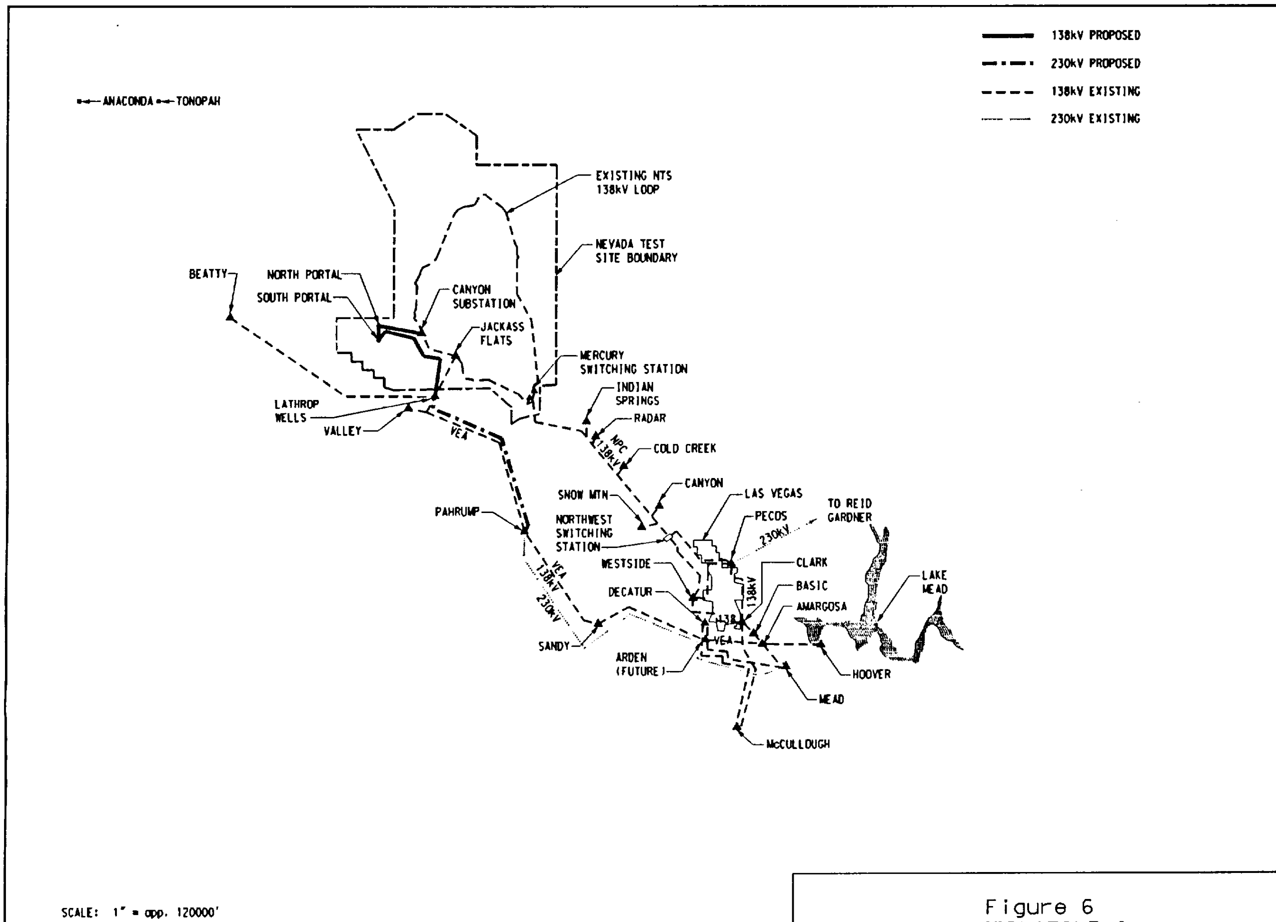

Figure 6
ALTERNATIVE C

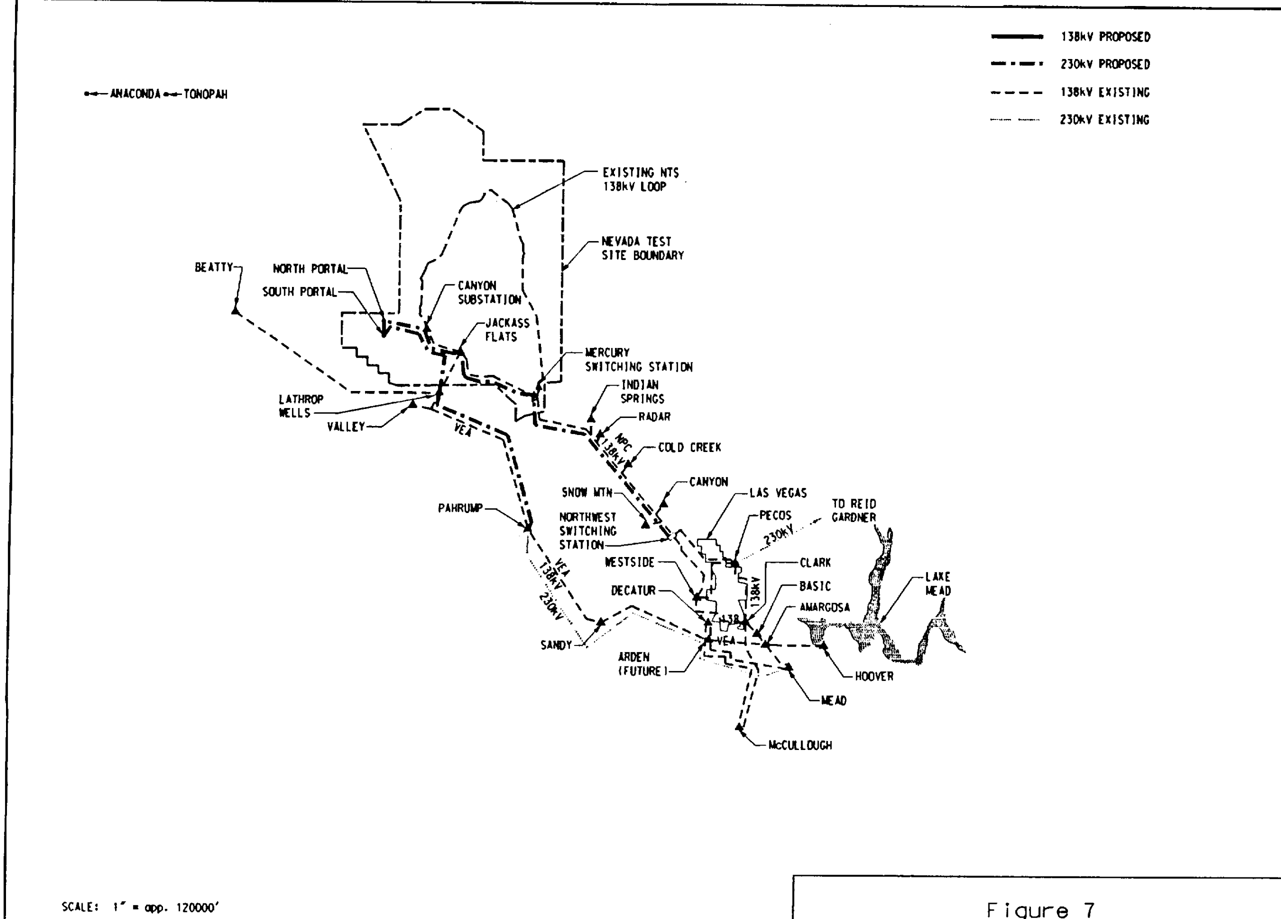

Figure 7
ALTERNATIVE D

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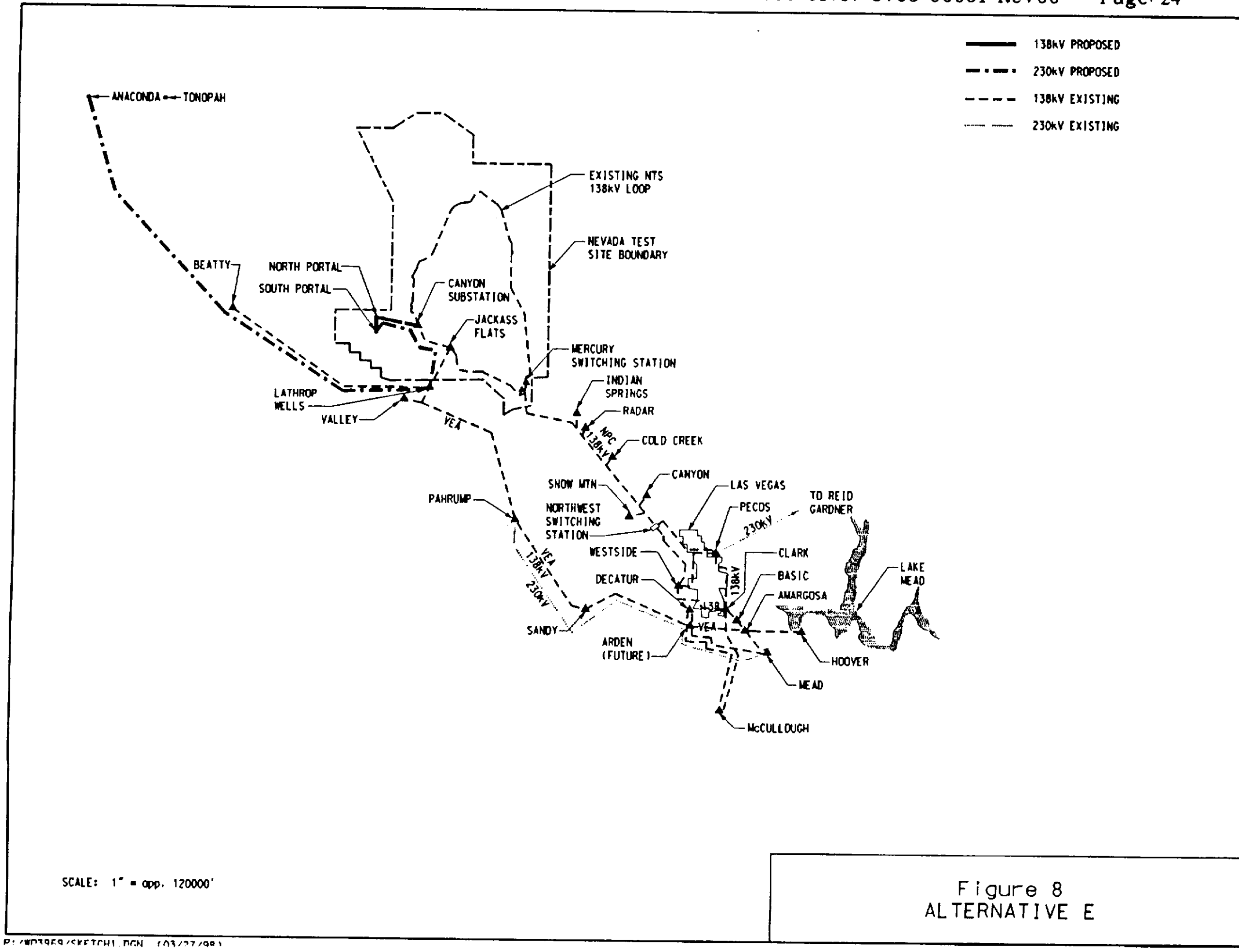

Figure 8
ALTERNATIVE E

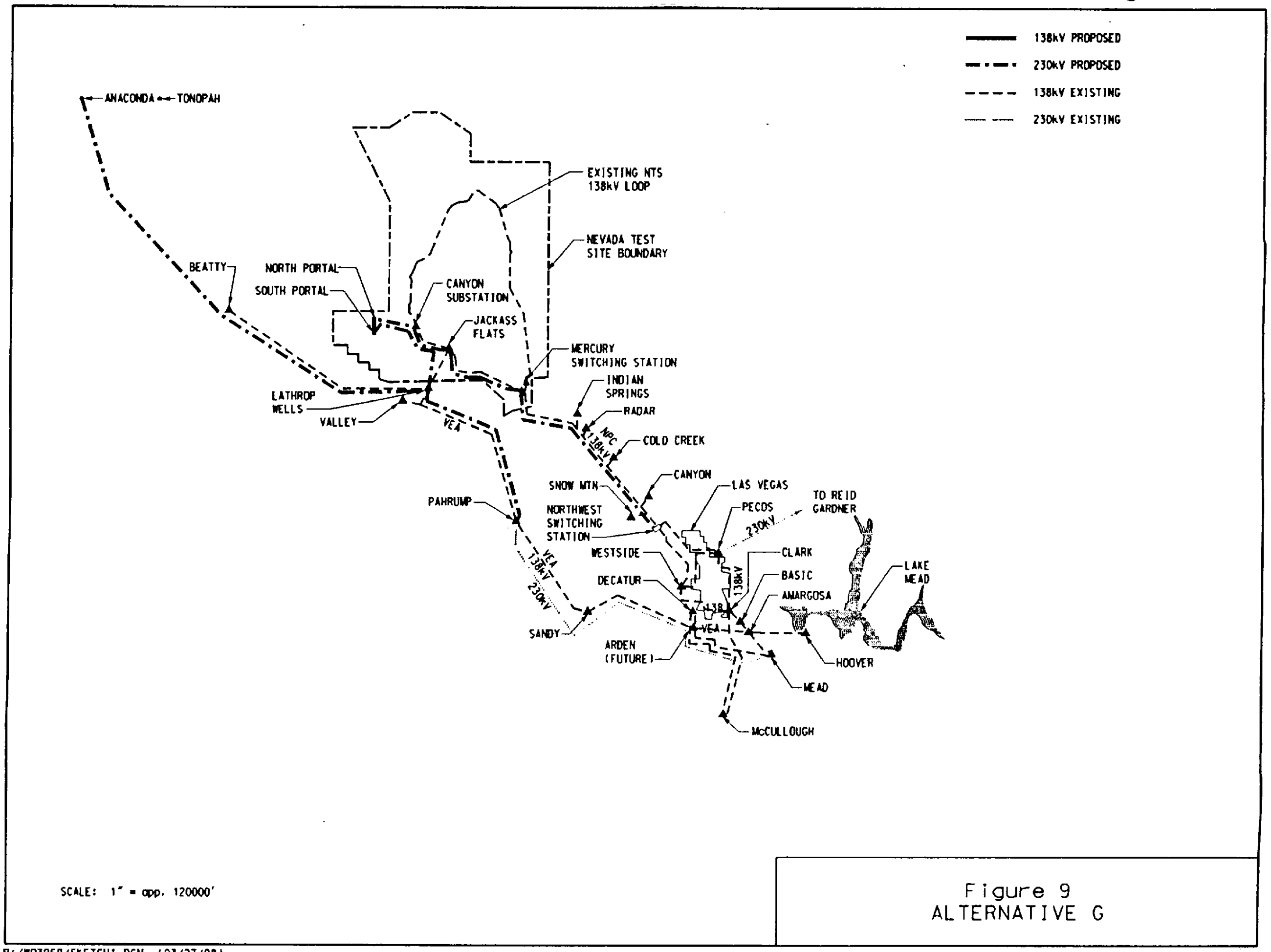

Figure 9
ALTERNATIVE G

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2.8.8 Discussion of Alternatives

The alternatives presented above are based on the assumption that a loop-type transmission system with firm capacity will be required, as indicated in Section 2.5.3. Further engineering development of off-site electrical utilities may enable consideration of other alternatives.

If the design requirements are revised through analyses developed in the near future, implementation of a radial transmission system should be considered; a short transmission line with a double circuit from a nearby transmission network may meet the operation requirements of the repository. Such alternatives should be considered as long as they meet repository construction and operation design requirements.

Alternative A strengthens the VEA system and gives the YMP project the power required; however, the capacity is not firm. With an outage of the 230-kV line, NPC would not be able to deliver the power required. This alternative must be used with Alternative B, E, or F for firm capacity.

Alternative B, like Alternative A, strengthens the NPC system and delivers the power required; similarly, this alternative must be implemented in combination with Alternative A, C, or E to achieve firm capacity.

Alternative C is similar to Alternative A, except that the 230-kV line ends at Lathrop Wells Substation and the autotransformer is placed at that point. This is the least costly alternative. However, this arrangement will not have sufficient backup power from NPC to achieve firm capacity.

Alternative D is an independent alternative for an entirely 230-kV system. It will have firm capacity in excess of any that could be desired, and will not require an autotransformer. The YMP would be completely independent of the NTS and would have the most reliable system, using mostly new equipment and introducing no autotransformer to reduce the reliability. The utility companies will no doubt wish to have an autotransformer installed at Mercury Switching Station, Jackass Flats Substation, or Lathrop Wells Substation to reinforce their systems, which would also allow VEA and NPC to expand their remaining 138-kV services.

Alternative D will yield more than adequate firm capacity, even if the YMP changes to medium- or low-density emplacement, as discussed in the *Mined Geological Disposal System Advance Conceptual Design Report* (CRWMS M&O 1996), which could conceivably more than double the anticipated loads. While the possibility of medium- or low-density emplacement is not currently anticipated, the off-site transmission system must be able to provide any power that may be required. In addition, construction delays and revised work plans to get back on schedule may greatly increase the construction loads, thereby increasing the connected load.

Alternative E is the only alternative that brings to the system a truly independent power source from a third utility, SPC. This alternative, like all of the others except Alternative D, is not firm. If the 230-kV line from Anaconda were to fail, the existing VEA and NPC lines would not be able to deliver the power required to all customers. If this alternative were used with a 230-kV transmission line extension to Pahrump Substation, all utilities involved would benefit, from a system perspective. This would allow the utilities to share power between them and greatly increase system reliability.

This 230-kV transmission line (approximately 160 miles) is the longest proposed line. It could probably not be cost-justified if it served the YMP alone. However, from a planning perspective, the utilities involved would ultimately derive the most benefit from this alternative, and they may be more willing to construct or share the cost for constructing this line than they would for the other alternatives. This alternative deserves in-depth study. If, for instance, Alternative E is combined with Alternative C (i.e., construct a 138-kV connector from Lathrop Wells Substation to the YMP and on to Canyon Substation, rather than construct a 230-kV line), it would reduce the cost of Alternative E, but would still be quite expensive. The utilities involved would need to conduct system studies to determine the impact on their systems.

Alternative F should be given the least consideration among the alternatives presented in this report because it would not provide firm capacity as a stand-alone system. If built, it should be built to 230-kV standards for future conversion, especially since the existing 138-kV lines into North West Switching Station were built in this fashion.

Alternative G is a composite of Alternatives D and E. It is not recommended for the YMP; however, the three utilities, SPC, NPC and VEA, may have an interest in this arrangement.

2.8.9 Relative Cost Comparison

The relative costs for the alternatives, shown in Table 4, were developed from per-unit quantities, included in Appendix C. For more accurate analyses, these costs will need to be adjusted to reflect actual line routing, conductor sizing, and equipment ratings.

The estimated cost for each alternative will be shared by the public utilities and the YMP. The cost will be shared among the parties as determined by discussions with the utilities.

Table 4. Alternatives Cost Comparison Summary

Alternatives	Estimated Cost ($ million)
Alternative A	24.0
Alternative B	32.0
Alternative C	20.8
Alternative D	52.3
Alternative E	48.2
Alternative F	23.4
Alternative G	86.1

The cost estimate presented for each scenario is a stand-alone estimate for the arrangement depicted. If alternatives are combined, it will be necessary to review the cost estimates and eliminate duplicated costs. For example, the estimated cost of the YMP switchyard is included in most system scenarios; this cost must be removed from one of the scenarios if that scenario is combined with another one that also includes the switchyard.

Improvements made at the 230-kV level will cost more than those made at the 138-kV level; however, in terms of capacity gained, and therefore of long-term system reliability, 230-kV improvements may prove to be the best alternative. The relative difference is compared in Table 5.

Table 5. Cost and Percent Increase

	138 kV	230 kV	Percent Increase (230 kV over 138 kV)
Transformers	$12,000 per MVA	$11,000 per MVA	-5
Transmission Line	$146,000/mile	$173,000 per mile	18
Circuit Breakers	$215,000 each	$350,000 each	62
Gang-operated Switch	$24,000 each	$35,000 each	45

The 230-kV circuit breakers and switchyard components are considerably more expensive than their 138-kV counterparts, but few are needed, and their cost in relation to total cost is small. The only other significant cost is in transmission line construction, which is about 20 percent greater for 230 kV than for 138 kV. This cost may be compensated for by the increase in energy efficiency, increased capacity, and improved voltage regulation.

A well planned transmission line for the YMP project will benefit not only the YMP, but the NTS, NPC, VEA, and SPC if they tie into the system. Construction, operation, and maintenance of the line deemed most appropriate will involve much discussion and negotiation. The lines will probably be paid for jointly by some or all of the utilities and users involved. Good planning will enhance the utilities' ability to transmit power throughout the area and result in greater reliability.

2.8.10 Observations

A detailed construction schedule for the off-site utilities implementation is needed to define critical milestones such as the start and ending dates for main tasks, environmental impact statement submittal date, and permitting period start and ending dates.

Discussions and load-flow studies with the three utilities, VEA, NPC, and SPC, must be conducted. The anticipated deregulation of the power companies by 2002 or earlier makes these issues even more complex. Load-flow studies of power flow involving SPC may determine quickly whether a transmission line connecting the SPC to a system with NPC and/or VEA is a desirable system improvement with economic justification, or whether such an option can be immediately dismissed.

Preliminary agreement must be reached with one or more public utilities operating in the area to define with more accuracy the cost and responsibilities for implementing the transmission system for the YMP.

Further studies and analyses are needed to determine with greater accuracy the level of reliability required for the off-site electrical utilities to support the construction and operation of the repository. These reliability analyses should be sufficiently comprehensive to include economic analyses of alternatives.

Construction at the YMP is scheduled to begin in 2005. The load will start low and rapidly grow over the first 4 or 5 years of the project. If the required power system is not in place at the start of the project, scheduling problems will be created and YMP construction will be delayed.

Some components of the new transmission system can be installed concurrently (i.e., switchyards, substations, and transmission lines). The transmission lines, both for construction and for engineering, will take the longest to install (1½ to 3 years), depending on the final system. It is possible that the transmission power loop can be single-ended at the start of the project and closed by the fourth year, when power demands and reliability become more important for construction and emplacement.

As scheduling becomes a more critical concern, options become limited. The first option, because of the shortest distance, would be the 230-kV line from Pahrump Substation to Lathrop Wells Substation, ±50 miles, and a 230-kV line to the YMP from Lathrop Wells Substation. This would give reliable power of adequate capacity; however, it is not firm.

Over the long term, a 230-kV loop independent of the 138-kV NTS loop is desirable, with 100 percent firm capacity for the loads of the YMP and utility customers. The NTS, as well as other loads, could be strengthened by installing an autotransformer to connect the new 230-kV loop to the existing 138-kV loop anywhere in the system.

The present 69-kV service for the YMP will remain to service the off-site loads; i.e., booster pump stations, until the new installation is complete. At that time, it will be decided either to maintain the 69-kV service for the off-site loads or to provide new 12.47-kV feeders from the new substations.

2.9 CONCLUSIONS AND RECOMMENDATIONS

2.9.1 The information provided in this report, obtained from previous studies, reveals that there will be a severe shortage of electrical power for the YMP repository. The present 10-MVA service from the NTS is inadequate for the repository future load requirements. Because neither VEA nor NPC can supply the firm power required at the YMP, two new transmission lines must be built by the public utilities. These lines are recommended to be built at 230 kV.

2.9.2 We recommend building a VEA 230-kV transmission line from Pahrump Substation to Lathrop Wells Substation, and also an NPC 230-kV line from North West Switching Station to Jackass Flats Substation, as in Alternative D (Section 2.8.4). We recommend further that this line operate at 230 kV from the outset. If this is not feasible because of the voltage conversion of the Pecos Substation to North West Switching Station line, the new line may be operated at 138 kV and converted to 230 kV later.

2.9.3 We recommend that the transmission system built to serve the YMP be a 230-kV loop-type (Lathrop Wells Substation to the YMP to Jackass Flats Substation) system connecting VEA with NPC, entirely independent of the NTS. This entire 230-kV transmission system is depicted in Figure 7 for Alternative D.

2.9.4 We recommend that preliminary discussions be started with NPC and VEA in 1998 to allow them time to analyze their systems, run load-flow analyses, and form some basis for discussion. Load-flow studies of power flow may determine quickly whether a transmission line connecting the SPC to a system with NPC and/or VEA is a desirable system improvement with economic justification, or whether such an option can be immediately dismissed.

2.9.5 We recommend that the YMP select a new electrical service for the repository through a competitive bidding process, including all the public utilities that operate in the vicinity of the YMP. We believe that obtaining service directly from a large public utility will bring the most benefit to the YMP.

2.9.6 We recommend that further analyses be conducted in the near future to confirm the conclusions and recommendations of this preliminary assessment. The analyses should include load flow studies considering the forecast YMP loads as discussed herein, and the system capacity improvements proposed in this technical document. Moreover, reliability and cost analyses should be developed to determine the most economical and reliable system for the YMP.

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3. WATER SUPPLY

3.1 OBJECTIVE

This section identifies upgrades to the off-site surface water supply system needed to meet water requirements for the repository surface and subsurface facilities during construction and operation.

3.2 SCOPE

This section identifies water sources and determines the capacity of the water tanks, pumps, and pipeline required to deliver water to the repository facilities. The existing water supply system, which draws water from Well J-13, consists of pumps, storage tanks, and a pipeline to the North Portal area. This section examines the existing ESF water supply system, estimates water needs for repository construction and operation, and identifies upgrades to the ESF water supply system needed for repository construction and operations. The engineering scope of work interfaces need to be resolved.

Design analyses and studies of the surface and subsurface facilities form the basis for the water requirement calculations; additional data were received from equipment manufacturers and suppliers.

No computer programs were used to develop the water supply system configuration and capacity.

3.3 BACKGROUND

To determine which upgrades to the off-site water supply system are required, it is first necessary to estimate potable and industrial water requirements for 1) Construction and operation of the subsurface facilities and 2) Construction and operation of the surface waste receiving and handling facilities.

Subsurface construction requires water for the underground activities, such as excavation and dust suppression, and for related surface facilities, such as sanitary needs and fabrication of concrete segments and washing underground equipment. These activities, which will be conducted at or through the South Portal, will require a water supply system to this area. Minimal construction activities will be carried out through the North Portal; water supply for these activities at that location can be drawn from the surface waste handling facilities water supply. Subsurface emplacement will be conducted through the North Portal and will require a water main through the North Portal.

The water calculations for the subsurface construction and operations, serviced through the South Portal, are detailed in Appendix D. The water supply needed for constructing and operating the surface waste handling facilities was obtained from the surface facilities design documents (referenced in Section 3.7).

3.4 DESIGN REQUIREMENTS

3.4.1 Surface facilities at the South Portal require potable water for drinking, showers, and lavatories at the offices and workshops; and industrial water for the concrete batch plant (subsurface cast in place and precast segments), dust suppression at conveyor dump points and on gravel roads, fire protection for buildings, and equipment washing bays.

3.4.2 Underground construction and development activities at the South Portal require industrial water for the following uses.

- Rock excavation equipment
- Washing walls for geologic mapping and before placing concrete segments and cast-in-place lining
- Dust suppression
- Fire suppression
- Potable water for drinking.

3.4.3 Development and emplacement shaft construction at the South Portal requires industrial water for the raise borer, the shaft down reamer, and placing the concrete lining.

3.4.4 Plumbing providing water for human consumption shall be lead-free, in compliance with 42 USC 300g-6 (OCRWM YMP 1994, Section 3.7.3.3.A).

3.4.5 The potable water system shall be designed and installed to comply with all federal, state, and local requirements, administrative authorities, and process and sanctions regarding the provisions of safe drinking water (OCRWM YMP 1994, Section 3.7.3.3.B).

Potable water will require chlorination equipment and separate tank storage. The water supply system is based on peak water consumption per year for each phase of construction and operation (OCRWM YMP 1994).

3.4.6 The water system shall be designed in accordance with DOE Order 6430.1.A, Division 2, Site and Civil Engineering, and Division 15, Mechanical, and applicable state laws (OCRWM YMP 1994, Section 3.7.3.3.C).

3.4.7 Any repository segment activity that may impact a drinking water source shall meet the requirements of the Safe Water Act, as amended (42 USC 300f et seq.; OCRWM YMP 1994, Section 3.3.11.3.A).

3.4.8 For nonpotable water, the repository segment interfaces with the (TBD) water supply system. The MGDS requires (TBD) gallons per day at a pressure of (TBD) pounds per square inch (OCRWM YMP 1994, Section 3.2.3.4.B).

3.5 REPOSITORY WATER SUPPLY SYSTEM

The following paragraphs compare the repository water supply needs to the existing water supply system. The water distribution system from the wells to the portal storage tanks is considered part of the off-site system. The water storage tanks and distribution systems at the North and South Portals are considered part of the on-site systems.

3.5.1 Water Source

Existing water wells, Wells J-13, J-12, and Well Complex C, are located in Basin 22 at Jackass Flats Substation (See Figure 10). These wells are the main source of water for the repository. Process water will be distributed from the well area to the North and South Portal areas, as shown in Figure 11 (CRWMS M&O 1998).

At present only Well J-13 is active. This well, which has a submersible pump with a capacity of 2,271 liters per minute (600 gallons per minute [gpm]), supplies water to the current North Portal ESF surface and subsurface construction and operation activities. The water permit approved for Well J-13 is limited to 430 acre-feet per year, or 530,000,000 liters per year (140,000,000 gallons per year) for site characterization from 1992 to 2002. According to current estimates (based on references in Section 3.7.3 and Appendix D), this quantity satisfies all repository water requirements in the future (CRWMS M&O 1998).

3.5.2 Well System Upgrade

To satisfy future needs for potable and industrial water at the repository surface and underground, the existing water supply system should be upgraded (CRWMS M&O 1996), as follows (See Figure 11):

- At Well J-13, the existing 189,250-liter (50,000-gallon) tank should be replaced with two water tanks, each with a capacity of 378,500 liters (100,000 gallons). At the same location, the two existing booster pumps, each with a capacity of 568 liters per minute (150 gpm), will be replaced with two new booster pumps, each with a capacity of 1,136 liters per minute (300 gpm).

- At the intersection between H Road and the South Portal Road is a second pump station. The two existing 568-liter-per-minute (150-gpm) booster pumps will be replaced with two new booster pumps, each with a capacity of 1,136 liters per minute (300 gpm). The two existing water surge tanks, each with a capacity of 75,700 liters (20,000 gallons), will remain unchanged. This existing pump station should be reconfigured to feed the North and South Portals either simultaneously or separately.

- An existing 254-millimeter (mm)-diameter (10-inch) pipe, 6,116 m (3.7 miles) long, connects the second pumping station to Wells J-12 and J-13. The existing pipeline is presently leaking and will be replaced.

- Well J-12 could serve as a backup source of water to guard against malfunction or failure of Well J-13 and to allow for maintenance of Well J-13. To accomplish this purpose, Well J-12 should be refurbished and equipped with a submersible pump of the same capacity as J-13.

- Well C (see Figures 10 and 11) is proposed to be equipped with an installation consisting of submersible well pump, two 75,700-liter (20,000-gallon) surge tanks, and two 1,136-liter-per-minute (300-gpm) booster pumps to serve as a backup source of water for Wells J-12 and J-13 in case of malfunction or failure.

3.5.3 On-site Water Storage and Distribution

Although not part of the off-site system, the following on-site storage tanks constitute the delivery points for the water and are described here for the sake of completeness (see Figure 11). At the North Portal, the industrial water storage will consist of one existing tank. For potable water storage, the existing tank will remain unchanged. The storage capacity shown in Figure 11 can provide for approximately 197,000,000 liters (52,000,000 gallons). At the South Portal, three industrial water tanks and one potable water tank will be needed. The supply to the subsurface facilities will rely on gravity.

At the development and emplacement shaft collars, single portable industrial water tanks will be installed. The tanks will be filled by water trucks.

3.5.4 Estimated Water Consumption

Quantities presented in this section are obtained from references in Section 3.7.

3.5.4.1 South Portal Surface Facilities Water Needs

Total potable water consumption for the construction, development, caretaker, retrieval, backfill, and closure phases, based on water peak consumption, is estimated to be 829,000,000 liters (219,022,000 gallons), for an average of 32,000,000 liters (8,454,000 gallons) per year. This annual quantity is required for a period of 26 years.

Industrial water for concrete fabrication, curing cast-in-place concrete, and dust suppression are estimated to require a total of 957,000,000 liters (252,840,000 gallons), equivalent to 40,000,000 liters (10,568,000 gallons) per year, for 24 years. In case of fire at the surface facilities, and to comply with NFPA regulations, 1,104,000 liters (291,680 gallons) of water must be available in tanks. This quantity is sufficient to supply 9,200 liters (2,400 gpm) of fire water for a period of 120 minutes.

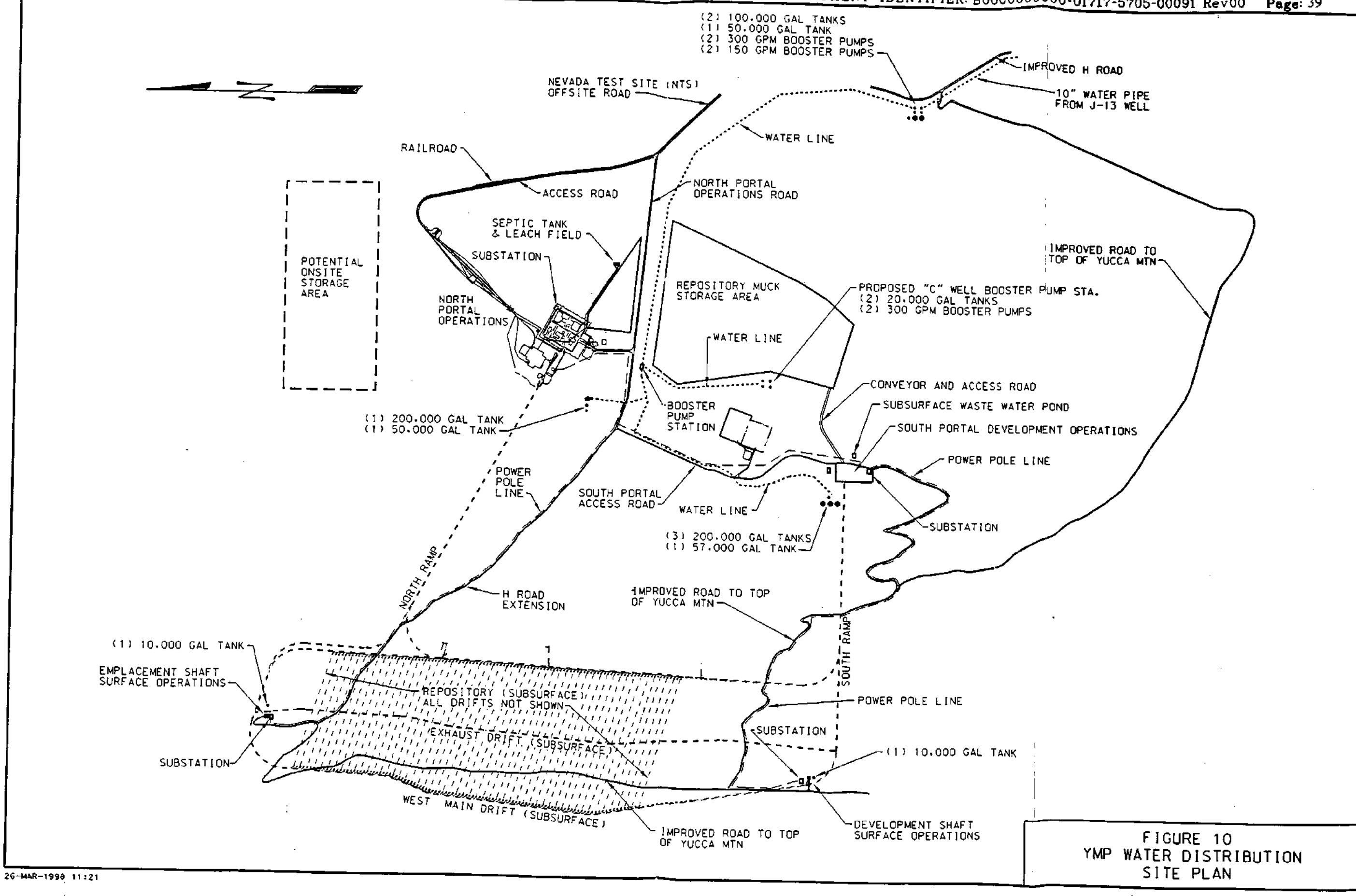

FIGURE 10
YMP WATER DISTRIBUTION
SITE PLAN

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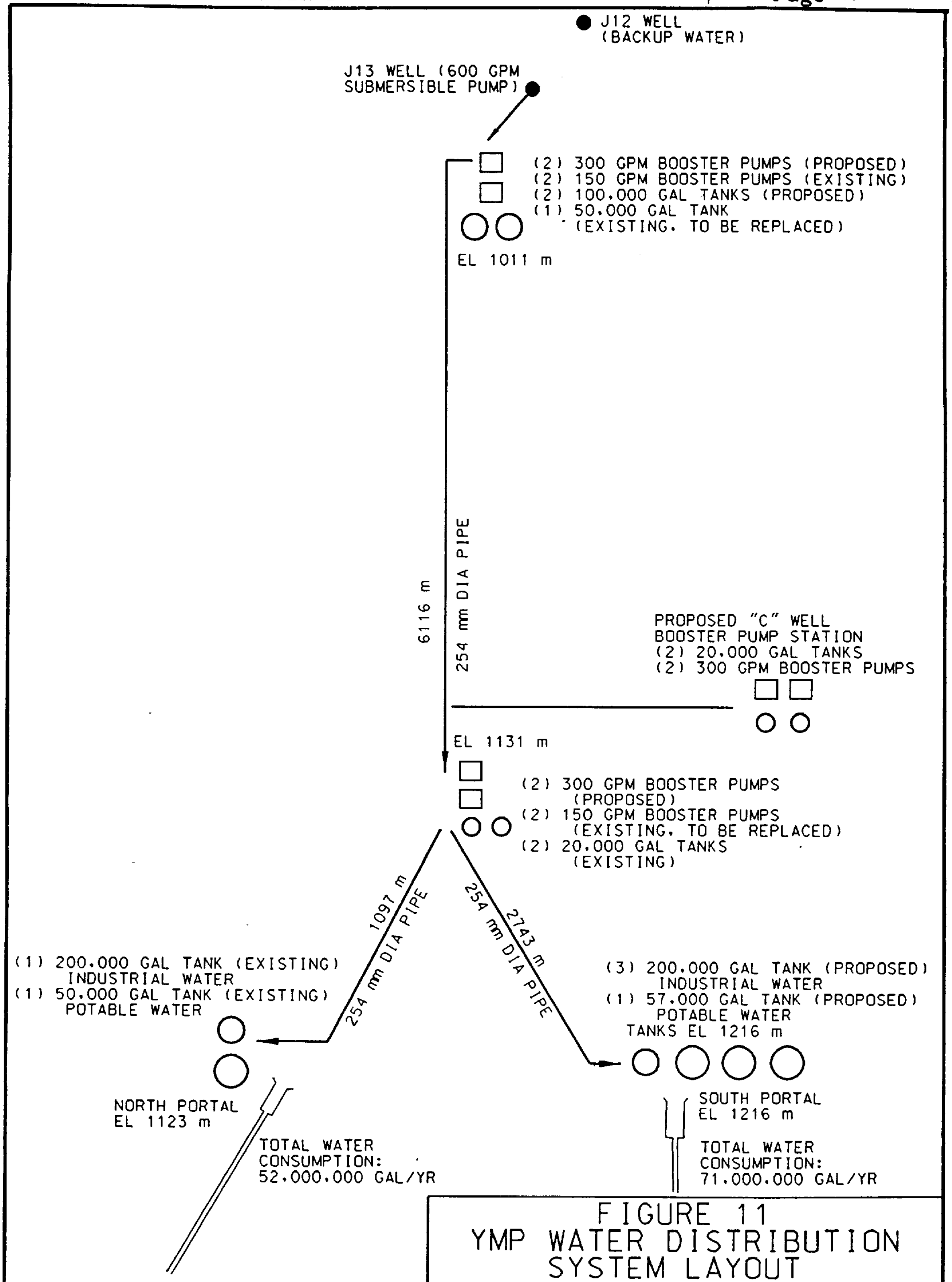

FIGURE 11
YMP WATER DISTRIBUTION SYSTEM LAYOUT

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3.5.4.2 South Portal Underground Repository Development

Potable Water - Drinking water is required for a period of 26 years. A total quantity of 74,000,000 liters (19,551,000 gallons) will be needed, which is equivalent to 3,000,000 liters (792,602 gallons) per year.

Industrial Water - Water consumption required for underground activities can be summarized as follows:

- Excavation equipment will require a total of 1,369,000,000 liters (361,691,000 gallons), or 53,000,000 liters (14,003,000 gallons) per year, for a period of 26 years.
- Cast-in-place concrete curing will require 30,000,000 liters (7,926,000 gallons), or 6,000,000 liters (1,585,000 gallons) per year, for a period of 5 years.
- Water to wash the excavation walls before the cast-in-place operation will require 162,000,000 liters (42,801,000 gallons), or 55,000,000 liters (14,531,000 gallons) per year, for a period of 3 years.
- Dust suppression will require 228,000,000 liters (60,238,000 gallons), or 9,000,000 liters (2,378,000 gallons) per year, for a period of 26 yrs.

3.5.4.3 Total South Portal Water Needs

Total consumption at the South Portal for both the surface and underground activities is estimated at about 3,900,000,000 liters (1,030,383,000 gallons), including 200,000,000 liters (52,840,000 gallons) for contingency purposes. Assuming that about 250,000,000 liters (66,050,000 gallons), or 6 percent of the water can be recovered and recycled, a total of 3,653,000,000 liters (964,332,000 gallons) will be needed. The peak usage is 268,427,000 liters per year (71,000,000 gallons per year) during the 26-year construction period.

3.5.4.4 North Portal Facilities Water Needs

The North Portal waste-handling facilities will require a total of 5,110,000,000 liters (1,350,066,000 gallons), which is equivalent to 196,000,000 liters per year (52,000,000 gallons per year) for 26 years. The subsurface emplacement operations will draw water from the surface storage tanks as needed for operational purposes, and for fire fighting if needed.

3.5.4.5 Total Repository Water Needs

The combined estimated water requirements for repository construction and operations amount to a maximum of 464,427,000 liters per year (123,000,000 gallons per year or 377 acre-feet per year) for a 26-year period. This maximum estimated requirement is close to the 430-acre-foot-per-year water permit for Well J-13 discussed in Section 3.5.1. After this period, water consumption will decrease. At this point, the repository off-site water supply system can continue to provide water for caretaker operations by operating at a reduced capacity, without substantial modifications. Additional calculations will be needed to estimate water requirements for retrieval and closure operations.

The repository water requirements presented in this section do not represent the YMP peak-year water requirement. The peak-year requirement, estimated to be approximately 430 acre-feet per year as requested by the YMP water appropriation permit application currently being evaluated by the Nevada State Engineer's Office, will be higher than the average.

3.6 CONCLUSIONS

The existing pump at Well J-13 can deliver 2,271 liters per minute (600 gpm), over 1 billion liters (264,300,000 gallons) per year, with an annual capacity well in excess of the site characterization permit limit of 530 million liters (140 million gallons). This quantity also exceeds the annual repository average demand of 335 million liters per year (88.6 million gallons). Well J-13 and its existing pump therefore have adequate capacity for repository construction and operational water needs. Additional tanks, booster pumps, and pipeline will be required to accommodate the repository surge and storage needs. Well J-12 and Well C can provide standby capacity to cover maintenance and emergency conditions at Well J-13. Well J-12 and Well C should be equipped with a pump similar in capacity to the one at Well J-13 to cover these eventualities.

3.7 REFERENCES

3.7.1 Codes and Standards

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Robbins Company. TBM, Raise Borer, & Shaft Down Reamer Equipment Manufacturing. 22445 76th Avenue, South Kent, Washington, 98032.

Tamrock Voest Alpine Company (Roadheader & Roofbolter Mfg.) 4853 Campbells Run Road, Pittsburgh, Pennsylvania, 15205.

3.7.3 Works Consulted

Construction & Tunneling Services. TBM design company. 1609 S Central Avenue, Suite H, Kent, Washington, 98032.

Dosco Roadheader Manufacturing 1997. *Advanced Technology for Rock Excavation Inc.* P.O. Box 309, Onaping, Ontario, Canada POM 2RO. June 13.

4. COMMUNICATIONS

4.1 OBJECTIVE

The off-site communications system that is currently in use at the YMP is part of the NTS's link to the Federal Telecommunications System (FTS). The FTS was built prior to the inception of the Yucca Mountain Project and prior to widespread use of personal computers. The YMP is expected to generate computer data that exceed the FTS network capacity; a growth in network data routing will require expansion of FTS networks. The FTS in its present form will not accommodate the requirements of a new computer wide area network (WAN) expected to be required for the YMP. The YMP will be a highly computerized site, with computer systems monitoring and operating critical systems on site. There will be computers and work stations located at almost every desk and work location on the site. Most of the data from these systems is planned to be available on the WAN with access to this information from all required government and private contractor offices. Because the existing FTS at this site is inadequate for this task, it must be expanded and modified to accommodate the expected use at the YMP. This report reviews and recommends viable communications options for off-site communication for the YMP.

4.2 SCOPE

The YMP repository construction and operation will need more off-site communication capability for transfer of data and voice to and from off-site locations than is currently available through the FTS. The currently existing site communications network will have to be expanded, modified, and updated to meet the needs of the YMP project. Design life of the modernized communication system is to extend through the caretaker phase.

Design of the data and voice communication systems will consist of several local area networks (LANs) and WANs connected to a backbone between the site and Las Vegas. Administrative and processing LANs will be accessed by means of a multimegabit WAN.

Off-site communications will include the YMP site to and from government and contractor offices in Mercury, Area 25, Las Vegas, and other areas of the United States. Expanded communications will include the YMP site to and from all waste generators and interim storage sites. Additional off-site communications will be used to track all in-transit waste packages as they move to the site. Bidirectional voice and data communications will be used by all in-transit waste transports and transport personnel during the waste transport process.

All reasonable, currently available technologies, as well as newly emerging communications systems, will be evaluated to determine the best form or forms of communications to be installed at the YMP. Regional service agents are not included for consideration in this technical document. Further analyses will be performed before technical design to determine the interface between regional service agents and off-site communications.

4.3 BACKGROUND

The YMP project currently uses microwave transmission and copper and fiber optics telephone lines for voice and data communications to off-site locations. The existing system is used for voice and data communications between the YMP site and the Area 25, Mercury, and Las Vegas engineering and management offices, as well as other sites throughout the country. The current on and off-site communications are through the FTS, the DOE/NV system, and commercial local and long- distance networks.

Communications to waste generator site locations are currently supplied by commercial long-distance telephone service. Some of the communications for the waste transport system are not in place at this time. Facsimile data transmission will also be used for communications from the generator's site and YMP site offices.

4.4 DESIGN REQUIREMENTS

4.4.1 The *Transportation System Requirements Document* (DOE 1996), Section 3.2.4.3.4, states that communications equipment shall be capable of protecting and safeguarding information from the waste generator locations and the YMP site in accordance with 10 CFR 73.21.

4.4.2 Communications requirements between the YMP site and all waste transports and transport personnel call for use of citizens band (CB) radio, radiotelephone, and other equivalent equipment approved by the Nuclear Regulatory Commission in accordance with DOE 1996 and 10 CFR 73.

4.4.3 The communication system must allow for continuous voice and data transmission between the site and all transport units during transport in accordance with 10 CFR 73.37.

4.4.4 In transit transport personnel must also maintain voice contact at a minimum of every 2 hours to the YMP site and the transport tracking personnel per 10 CFR 73.

4.4.5 The communications system shall be secure in accordance with 10 CFR 73.21(g).

4.4.6 Communication systems shall be designed in accordance with the applicable sections of DOE Order 6430.1A, Division 1, Division 2, Division 10, Division 13, Division 15, and Division 16 (OCRWM YMP 1994, Section 3.7.3.4.A).

4.4.7 The communications network shall provide a telephone system, a two-way radio communications system, and an alarm system. The telephone system shall provide direct communication between the repository, the existing NTS network, and the off-site commercial system (OCRWM YMP 1994, Section 3.7.3.4.A.1).

4.4.8 Off-site communications shall also provide for dial-access data transmission lines to off-site locations via long-distance toll and FTS services (OCRWM YMP 1994, Section 3.7.3.4.A.2).

4.4.9 The repository segment interfaces with the NTS switched telephone system at (TBD). The MGDS requires:

1. (TBD) FTS lines with (TBD) quality
2. (TBD) commercial long-distance lines with (TBD) quality
3. (TBD) lines to the local NTS exchange with (TBD) quality
4. (TBD) private lines

The required security alarm stations shall have conventional telephone service for communications with law enforcement authorities (OCRWM YMP 1994, Section 3.2.3.4.D).

4.4.10 The repository segment will interface with the NTS emergency radio net. This net uses:

1. (TBD) channels
2. (TBD) frequency
3. (TBD) bandwidth
4. (TBD) private lines

To provide the capability of continuous communication, two-way radio voice communication shall be established in addition to conventional telephone service between local law enforcement authorities and the facility, and shall terminate at the facility in a central alarm station within the protected area (OCRWM YMP 1994, Section 3.2.3.4.E).

4.4.11 Communications facilities shall be designed in accordance with the applicable sections of DOE Order 6530.1A, Section 1630-99.8, Telecommunications, Alarms, and Automated Data Processing (ADP) Centers and Radio Repeater Stations (OCRWM YMP 1994, Section 3.7.3.4.B).

4.4.12 Communication with program operations and management at the Central Management and Operations Control Center will be by the commercial telephone system (OCRWM YMP 1994, Section 3.7.3.4.G).

4.5 ASSUMPTIONS

No assumptions that applied to off-site communications were found in the *Controlled Design Assumptions Document* (CRWMS 1997). The following assumptions are needed for this evaluation of the YMP communications system:

4.5.1 The off-site communications system for the YMP project will be established through the connection with the FTS. The FTS will be expanded and modified to accommodate the expanded usage. Voice communications will be available from the YMP site to all government offices throughout the United States through the FTS and local and national communications companies.

4.5.2 Voice communications will be available from the YMP site to all waste generators and individuals through an FTS interconnection with local telecommunications networks.

4.5.3 Satellite communication will be used as part of the in transit waste transportation tracking and communications system.

4.5.4 Waste transport personnel will use cellular telephones, satellites, the Global Positioning System (GPS), and radios for communications and waste container location fixes with the YMP site and local and state agencies during transport of waste.

4.5.5 The use of video information from the waste transport units will be evaluated.

4.5.6 All authorized data stored in computers at the YMP site must be available over the WAN from other authorized government or contractors offices. Critical data that must be transmitted on the WAN will be protected in accordance with 10 CFR 73.21.

4.5.7 The band width of this communications network will be large enough to allow for high speed transfer of data across the WAN.

4.5.8 Site-specific LANs will be connected into the WAN to allow access of site data from authorized personnel.

4.5.9 The telecommunications network will handle voice, video, and data. This system will be capable of handling communications from on and off site as required by the project.

4.6 ASSESSMENT

Data will be generated by monitoring computers, administrative LANs, and voice communications, with backbone transmission rates in multimegabits per second.

The off-site communications system will be discussed in three parts. The first part is the communications between the YMP site and the government offices in Area 25, Mercury, Las Vegas, and other government facilities throughout the United States. The second part is the communications between the YMP site and the waste generators. The third part is the communications between the YMP site and the waste transport units and transport personnel.

4.6.1 Government Facilities

Communications between the YMP site and government offices will include Area 25, Mercury, Las Vegas and, other government offices throughout the United states. This expanded communications system will become part of the FTS. The system will include voice, high-speed data transfer, and video capability (OCRWM YMP 1994).

4.6.2 Waste Generators

Communications between the YMP site and waste generator offices and sites of waste generation is also critical. These communications will consist of voice, data, video, and facsimile communications between the YMP site and waste generator offices. This communications system shall be secure in accordance with 10 CFR 73.21(g).

4.6.3 Waste Transport Personnel

Communications between the YMP site and the waste transport personnel are critical to the waste transport system. This communication system must allow for continuous voice and data transmission between the site and all transport units during transport in accordance with 10 CFR 73.37. Communications between the transport units and all local and state police agencies along the path of transport is also required. The waste packages shall be tracked as to location, speed of travel, integrity of transport system, and any other data as defined in subsequent analysis. In transit transport personnel must also maintain voice contact at a minimum of every 2 hours to the YMP site and the transport tracking personnel per 10 CFR 73. Video information may also have to be transmitted from the transport units to the YMP site.

4.7 DISCUSSION

The capacity of the currently existing FTS system to support the expanded scope of work at the YMP site during the construction and operation phases of the project is limited. The FTS is currently installing a fiber optics line along the main site power feed route. This system is not complete as of the date of this report, nor is it known what the system capabilities will be. The communications design team will have to assess the capabilities of this new system and determine whether it will meet the requirements of the project.

The current bandwidth on the existing FTS microwave link is limited and cannot accommodate expansion to transmit the gigabytes of data that will be required for the YMP. The WAN will be constructed through the coordination of the FTS to serve the YMP site and its remote operations. The WAN will constitute a high-speed network connecting the YMP site computers and control/monitoring systems to government and contractors offices in the Las Vegas and other appropriate sites.

Communications between the waste generator sites will take place over the standard telecommunications systems already existing to these sites. If high-speed data communications are required to these sites, dedicated telecommunications lines can be leased from the available telecommunications companies. Protection for data and facsimile information from the waste generator sites will comply with 10 CFR 73 and the requirements of the NRC.

Communications between the YMP and waste transport units will be the most difficult to implement. CRWMS (1996) and 10 CFR 73 require communications to each of the waste transport units, as required. This includes all transports that are by truck, rail, or ship and barge. Communications requirements between the YMP site and all waste transports and transport personnel calls for the use of citizens band radio, radiotelephone, and other equivalent NRC-approved equipment in accordance with DOE 1996 and 10 CFR 73.

A shift in technology over the last 10 years has, for the most part, eliminated the use of radiotelephones, which have been replaced by cellular telephones. Cellular telephones will be standard equipment for the transport units; new technology now allows facsimile and data transmission from the units as well as voice. New digital cellular telephone systems also allow encryption of conversations and data to ensure compliance with 10 CFR 73. Cellular telephone systems are currently in place throughout the country and, by the time the transport system is in place, will allow continuous communications to and from the waste transport units and the YMP site. The satellite tracking system discussed below will be used as a backup to the cellular telephone system. Communications between the vehicles in the transport units can continue to take place by CB radios or commercial band frequency-modulated radios.

Using currently existing satellite technology, vehicle or waste packages can now be tracked in any location in the United States or the world. Commercial trucking companies currently use satellite communications technology for tracking, monitoring, and communicating with their trucks and personnel; such a system could be adapted to the requirements of tracking the waste transport unit. These systems can monitor truck and tractor operating status, location, speed, direction of travel, and history of travel and operation. A small computer dedicated to this purpose is located on the tractor.

These systems are integrated with a GPS receiver that will give the tractor's location. This computer system with GPS is connected with a satellite up/down link antenna that would allow a central station to query the tractor or allow communications to its operators at any time or location. The ability to track the waste package location at any time, as well as the capability of monitoring and bidirectional communications, would augment the communications to the transport units.

4.8 RECOMMENDATIONS

4.8.1 YMP Site Communications and the FTS

The microwave, optical fiber, and copper-wire systems in the current FTS must be upgraded to ensure that adequate telecommunications capability is available from the YMP site to the engineering and operations offices in Las Vegas, other engineering offices, and other government locations around the United States.

The system needs to support a high-speed WAN as well as expanded voice and video communications capabilities. The new fiber optics system currently being installed should be able to accommodate the requirements of the expanded communications network.

4.8.2 Waste Generator Site Communications

Waste generators will require communications to the YMP site. The communications requirements are not extensive and can be readily met by the local telecommunications companies serving these facilities. If developments in the future require more extensive communications to these sites, leased or dedicated telecommunications lines can be added by the local communications companies.

4.8.3 Waste Transport Communications

The communications requirements to the waste transport group are very extensive. The voice and data communications capabilities of the transport group could be met by using available and anticipated cellular telephone technology. Data encryption can be used with this technology to ensure secure communications. Waste packages can be tracked using currently existing satellite communications technology. Satellite tracking of the waste packages can ensure that the precise, real-time status and location of the waste is available to the YMP site personnel.

Because off-site communications at the YMP site do not currently meet the requirements and because communications systems are undergoing dramatic changes, the following tasks should be undertaken:

- Perform a systematic and comprehensive study to determine all of the available alternatives for the WAN and voice communications system for the YMP.

- Perform a systematic and comprehensive study to determine which cellular telephone technology and frequencies should be used for communication to the waste transport units.

4.9 REFERENCES

4.9.1 Codes and Standards

4.9.1.1 U.S. Department of Energy

DOE [U. S. Department of Energy] 1989. DOE Order 6430.1A, *General Design Criteria,* Section 1670, Exterior Communications and Alarm Systems, and Section 1671, Interior Communications and Alarm Systems. Washington, D.C. April 6.

4.9.1.2 National Fire Protection Association

NFPA [National Fire Protection Association] 70. NFPA 70, *National Electrical Code 1996* (NEC). Quincy, Massachusetts: National Fire Protection Association. 1995.

4.9.1.3 Code of Federal Regulations

10 CFR 72. *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste.* January 1, 1997. Washington, D.C.: U.S. Government Printing Office.

10 CFR 73. *Physical Protection of Plants and Materials.* January 1, 1997. Washington, D.C.: U.S. Government Printing Office.

49 CFR 174. *Carriage by Rail.* October 1, 1997. Washington, D.C.: U.S. Government Printing Office.

49 CFR 176. *Carriage by Vessel.* October 1, 1997. Washington, D.C.: U.S. Government Printing Office.

49 CFR 177. *Carriage by Public Highway.* October 1, 1997. Washington, D.C.: U.S. Government Printing Office.

4.9.2 Documents Cited

CRWMS M&O 1997. *Controlled Design Assumptions Document.* B00000000-01717-4600-00032, Rev. 04. ICN 3. Las Vegas, Nevada: CRWMS M&O. November 19.

DOE 1996. *Transportation System Requirements Document.* D00000000-00811-1708-00002, Rev. 2. DOE/RW-0425. June.

OCRWM YMP [U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Yucca Mountain Site Characterization Project] 1994. *Repository Design Requirements Document.* YMP/CM-0023, Rev. 0. July. ICN 1, September 22.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

APPENDIX A

ACRONYMS AND ABBREVIATIONS

A

ANSI	American National Standards Institute

C

CFR	*Code of Federal Regulations*
cm	Centimeter
CRWMS	Civilian Radioactive Waste Management System
cu.	Cubic

D

dia.	Diameter
DOE	United States Department of Energy

E

eds.	Editors
ESF	Exploratory Studies Facility

F

FTS	Federal Telecommunications System

G

gpm	Gallons per minute

H

hr	Hour

I

IEEE	Institute of Electrical and Electronics Engineers

K

kg	Kilogram
kV	Kilovolt

L

L	Liter
LAN	Local area network (computer)
lb	Pound

M

m	Meter
Mfg.	Manufacturing
MGDS	Mined Geologic Disposal System
min	Minute
M&O	Management and Operating Contractor
msl	Mean sea level
MVA	Megavoltampere
MW	Megawatt

N

N/A	Not applicable
NEC	National Electrical Code
NFPA	National Fire Protection Association
NPC	Nevada Power Company
NTS	Nevada Test Site

O

OD	Outside diameter

Q

QA	Quality Assurance

S

SCADA	Supervisory control and data acquisition
sht.	Sheet
SPC	Sierra Pacific Power Company

T

TBD	To be determined
TBM	Tunnel-boring machine
TBV	To be verified

V

VEA	Valley Electric Association
VMI	Value Management Institute

W

WAN	Wide area network (computer)
WBS	Work breakdown structure

Y

YMP	Yucca Mountain Project

APPENDIX B

ANNUAL LOAD DEMAND

APPENDIX B
ANNUAL LOAD DEMAND

The subsurface and surface loads were taken from currently available sources, such as the *Subsurface Construction and Development Analysis* (CRWMS M&O 1997a) and *Site Electrical System Technical Report* (CRWMS M&O 1998). References are in Section 2.10.

Table B-1. Preliminary Subsurface Electrical Load Construction Year 1

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CONSTRUCTION - YEAR # 1

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connecte Load (hp)	Connect Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (7.6 m) No 1	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (5.5 m) No 2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Headers No 1 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Headers No 2 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Drill Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	Overland Conveyor with Stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Underground Facilities		200.00						200.00			200.00	
	Lighting		520.00						520.00			520.00	
	Rail Transportation (5x120)		600.00						600.00			600.00	Assuming 1 hp=1 kVA
	Auxiliary Construction Fans (2x150hp)	300.00											
	Auxiliary Construction Fans (3x250hp)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Ventilation Fans at North Portal (3x250hp)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Dust Collector (2x150hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Welders		60.00						60.00			60.00	
	Water Pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	
	Batch Plant		200.00						200.00			200.00	
	South Portal Facilities		3000.00						3000.00			3000.00	

Total Connected Load (hp): 12816.00
Total Connected Load (kVA): 4580.00
Total Standby Load (hp):

Total Demand Load(kVA 14494.72
Total Actual Load (kVA):
Total Peak Load (kVA): 14494.72

Table B-2. Preliminary Subsurface Electrical Load Construction Year 2

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CONSTRUCTION - YEAR # 2

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connecte Load (hp)	Connect Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (7.6 m) No 1	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (7.6 m) No 3	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (5.5 m) No 2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	TBM (5.5 m) No 4	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Headers No 1 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Headers No 2 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Down Hole Shaft Reamer	1000.00			0.90	900.00	0.94	0.89	802.53			802.53	
	Drill Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	East Main Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	Overland Conveyor with stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Underground Facilities		400.00						400.00			400.00	
	Rail Transportation (6x120hp)		720.00						720.00			720.00	Assuming 1 hp = 1 kVA
	Lighting		770.00						770.00			770.00	
	Auxiliary Construction Fans (2x150hp)	300.00											
	Auxiliary Construction Fans (3x250hp)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Ventilation Fans at North Portal (3x250hp)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Dust Collectors(3x150hp)	450.00			0.90	405.00	0.93	0.87	373.41			373.41	
	Development Shaft Auxiliary Fan (1x150)	150.00			0.95	142.50	0.93	0.87	131.39			131.39	
	Welders		60.00						60.00			60.00	
	Water Pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	
	Batch Plant		200.00						200.00			200.00	
	South Portal Facilities		3000.00						3000.00			3000.00	

Total Connected Load (hp) : 21083.00
Total Connected Load (kVA) : 5150.00
Total Standby Load (hp) :

Total Demand Load(kVA 21515.55
Total Actual Load (kVA):
Total Peak Load (kVA): 21515.55

Table B-3. Preliminary Subsurface Electrical Load Construction Year 3

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CONSTRUCTION - YEAR # 3

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connecte Load (hp)	Connect Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (7.6 m) No 1	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (7.6 m) No 3	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (5.5 m) No 2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	TBM (5.5 m) No 4	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Header No 1 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Header No 2 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Down Hole Shaft Reamer	1000.00			0.90	900.00	0.94	0.89	802.53			802.53	
	Drill Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	East Main Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	Overland conveyor with stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Underground Facilities		600.00						600.00			600.00	
	Lighting		1020.00						1020.00			1020.00	
	Rail transportation (6x120 hp)		720.00						720.00			720.00	Assuming 1 hp = 1 kVA
	Development shaft hoist	250.00											
	Development Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	AuxiliaryConstruction Fans (3x150)	450.00			0.90	405.00	0.93	0.87	373.41			373.41	
	Auxiliary Construction Fans (3x250)	750.00			0.90	675.00	0.94	0.89	601.90			601.90	
	Dust Collectors (3x150)	450.00			0.90	405.00	0.93	0.87	373.41			373.41	
	Water Pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	
	Batch plant	200.00			0.95	190.00	0.93	0.89	171.25			171.25	
	South Portal Facilities		3000.00						3000.00			3000.00	
	Welders		60.00						60.00			60.00	

Total Connected Load (hp): 22783.00
Total Connected Load (kVA): 5400.00
Total Standby Load (hp):

Total Demand Load(kVA 23147.45
Total Actual Load (kVA):
Total Peak Load (kVA): 23147.45

Table B-4. Preliminary Subsurface Electrical Load Construction Year 5

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CONSTRUCTION - YEAR # 5

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connecte Load (hp)	Connect Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	TBM (7.6 m) No 1	3290.00			0.90	2961.00	0.95	0.92	2527.35			2527.35	
	TBM (5.5 m) No 2	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	TBM (5.5 m) No 4	2252.00			0.90	2026.80	0.95	0.91	1748.98			1748.98	
	Road Header No 1 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Road Header No 2 (includ. Bendi car)	672.00			0.90	604.80	0.94	0.88	545.43			545.43	
	Ventilation Raise Boring Machine	400.00			0.90	360.00	0.93	0.87	331.92			331.92	
	Drill Jumbo	470.00			0.90	423.00	0.93	0.87	390.01			390.01	
	West Main Drift Conveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	South Ramp Conveyor	1200.00			0.90	1080.00	0.94	0.89	963.04			963.04	
	East Main Cconveyor	1425.00			0.90	1282.50	0.95	0.90	1119.00			1119.00	
	Exhaust Main Drift Conveyor	600.00			0.90	540.00	0.94	0.88	486.99			486.99	
	Overland conveyor with stacker	350.00			0.90	315.00	0.93	0.87	290.43			290.43	
	Compressor	250.00			0.90	225.00	0.93	0.86	209.86			209.86	
	Underground Facilities		800.00						800.00			800.00	
	Lighting		1270.00						1270.00			1270.00	
	Emplacement Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Emplacement Shaft Booster Fans	2500.00			0.90	2250.00	0.95	0.91	1941.58			1941.58	
	Development Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Auxiliary Construction Fans (2x150 hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	Auxiliary Construction Fans (1x250 hp)	250.00											
	Fixed HEPA filters (3x150 hp)	450.00			0.90	405.00	0.93	0.87	373.41			373.41	
	Mobile HEPA filters & Chillers			1000.00	0.90	900.00	0.94	0.89					
	Dust Collectors (3x150hp)	450.00			0.90	405.00	0.93	0.87	373.41			373.41	
	Water Pumps	135.00			0.95	128.25	0.92	0.87	119.53			119.53	
	Welders		60.00						60.00			60.00	
	Batch plant	200.00			0.95	190.00	0.93	0.89	171.25			171.25	
	South portal facilities		3000.00						3000.00			3000.00	

Total Connected Load (hp) : 24543.00
Total Connected Load (kVA) : 5130.00
Total Standby Load (hp) : 1000
Total Demand Load(kVA 23528.53
Total Actual Load (kVA):
Total Peak Load (kVA): 23528.53

Table B-5. Preliminary Subsurface Electrical Load for Caretaker Phase

PROJECT: OCRWM
LOCATION: YUCCA MOUNTAIN, NV
W.O.No: 3969
EQUIP No: CARETAKER-YEARS 29 thru 105

DATE: 02/28/98
BUS No:
VOLTS:

Equip No:	Description	Connecte Load (hp)	Connect Load (kVA)	Standby Load (hp)	Dem Fac	True Pwr Dem(bhp)	Eff	Pwr Fac	Demand Load (kVA)	Duty Fac	Actual Load (kVA)	Peak Load (kVA)	Remarks
	Rail Transportation, Personnel (2x60hp)	120.00			0.95	114.00	0.92	0.85	108.75			108.75	
	Underground Facilities		800.00						800.00			800.00	
	Lighting		1270.00						1270.00			1270.00	
	Emplacement Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Emplacement Shaft Booster Fans (2x1250)	2500.00			0.90	2250.00	0.95	0.90	1963.16			1963.16	
	Development Shaft Fan	2000.00			0.90	1800.00	0.95	0.90	1570.53			1570.53	
	Fixed HEPA Filters (2x150hp)	300.00			0.90	270.00	0.93	0.86	251.84			251.84	
	South Portal Facilities		1000.00						1000.00			1000.00	

Total Connected Load (hp) : 6920.00
Total Connected Load (kVA) : 3070.00
Total Standby Load (hp) :
Total Demand Load(kVA 8534.803
Total Actual Load (kVA):
Total Peak Load (kVA): 8534.80

APPENDIX C

ALTERNATIVE COST BREAKDOWN

APPENDIX C

ALTERNATIVE COST BREAKDOWNS

The relative costs for per-unit quantities in each of the alternatives are shown in Table C-1. Tables C-2 through C-4 compare the cost of each line segment, high-voltage switchyards, and principal components of each alternative. Unit costs were obtained from previous studies (Section 2.3); values were updated using typical escalation factors. Because some of the alternatives are not independent and must be used in combination with other alternatives, the components in each alternative are included and should be reviewed. In some combinations, an autotransformer or switchyard may be needed.

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	Major Components	Estimated Cost ($ million)
Alternative A	230-kV line from Pahrump Substation to Lathrop Wells Substation	10.4 mil
	230-kV line from Lathrop Wells Substation to YMP	4.0
	138-kV line from the YMP to Canyon Substation	1.1
	230-kV switchyard at Pahrump Substation (1 terminal)	0.74
	230-kV switchyard at Lathrop Wells Substation (3 terminals)	2.2
	YMP 230-kV switchyard (3 terminals)	2.2
	230-kV switchyard at Canyon Substation (1 terminal)	0.74
	138-kV addition to Canyon Substation (1 terminal)	0.54
	230/138-kV Autotransformer at Canyon Substation (50/66/85 MVA)	0.72
	230/138-kV Autotransformer at Lathrop Wells Substation (100/133/167 MVA)	1.4
	Total Alternative A	24.04

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	**Major Components**	**Estimated Cost ($ million)**
Alternative B	230-kV line from Northwest Switching Station to Mercury Switching Station	14.5
	Upgrade 138-kV line conductor from Mercury Switching Station to Jackass Flats Substation	1.7
	Upgrade 138-kV line conductor from Jackass Flats Substation to Canyon Substation	0.8
	138-kV line from Canyon Substation to YMP	1.1
	138-kV line from Lathrop Wells Substation to YMP	3.4
	138-kV Northwest Switching Station (2 terminals)	1.1
	230-kV Northwest Switching Station (2 terminals)	1.6
	138-kV addition to Canyon Substation (1 terminal)	0.54
	YMP 138-kV Switchyard (3 terminals)	1.62
	138-kV Lathrop Wells Substation (1 terminal)	0.54
	230-kV Mercury Switching Station (2 terminals)	1.2
	138-kV Mercury Switching Station (1 terminals)	0.54
	230/138-kV Autotransformer at Northwest Switching Station (100/133/167 MVA)	1.4
	230/138-kV Autotransformer at Mercury Switching Station (100/133/167 MVA)	1.4
	Reconnections in Pecos Substation Required to Connect Line to 230-kV Bus	0.6
	Total Alternative B	32.04

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	Major Components	Estimated Cost ($ million)
Alternative C	230-kV line from Pahrump Substation to Lathrop Wells Substation	10.4
	138-kV line from Lathrop Wells Substation to YMP	3.4
	138-kV line from Canyon Substation to YMP	1.1
	YMP 138-kV Switchyard (3 terminals)	1.62
	230-kV switchyard at Lathrop Wells Substation (3 terminals)	1.8
	230-kV switchyard at Pahrump Substation (1 terminal)	0.6
	138-kV addition to Canyon Substation (1 terminal)	0.5
	230/138-kV Autotransformer at Lathrop Wells Substation (100/133/167 MVA)	1.4
	Total Alternative C	20.82

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	Major Components	Estimated Cost ($ million)
Alternative D	230-kV line from Northwest Switching Station to Mercury Switching Station	14.5
	230-kV line from Pahrump Substation to Lathrop Wells Substation	10.4
	230-kV line from Lathrop Wells Substation to YMP	4.0
	230-kV line from Canyon Substation to YMP	1.2
	230-kV line from Mercury Switching Station to Jackass Flats Substation to Canyon Substation	6.1
	YMP 230-kV switchyard (3 terminals)	2.2
	230-kV switchyard at Pahrump Substation (1 terminal)	0.6
	230-kV switchyard at Lathrop Wells Substation (3 terminals)	1.8
	138-kV Northwest Switching Station (2 terminals)	1.0
	230-kV Northwest Switching Station (2 terminals)	1.2
	230-kV Mercury Switching Station (3 terminals)	2.2
	230-kV Addition to Canyon Substation (3 terminals)	1.8
	138-kV Switchyard at Mercury Substation (1 terminal)	0.54
	Reconnections in Pecos Substation Required to Connect Line to 230-kV Bus	0.6
	230/138-kV Autotransformer at Northwest Switching Station (100/133/167 MVA)	1.4
	230/138-kV Autotransformer at Mercury Switching Station (100/133/167 MVA)	1.4
	230/138-kV Autotransformer at Lathrop Wells Substation (100/133/167 MVA)	1.4
	Total Alternative D	52.34

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	Major Components	Estimated Cost ($ million)
Alternative E	Anaconda Substation to Lathrop Wells Substation (230-kV line)	33.2
	230-kV switchyard at Anaconda Substation (1 terminal)	0.6
	230-kV switchyard at Lathrop Wells Substation (3 terminals)	2.2
	138-kV switchyard at Lathrop Wells Substation (1 terminal)	0.54
	230-kV line from Lathrop Wells Substation to the YMP	4.0
	230-kV line from Canyon Substation to the YMP	1.2
	YMP 230-kV Switchyard (3 terminals)	2.2
	230-kV addition to Canyon Substation (2 terminals)	1.6
	138-kV addition to Canyon Substation (1 terminal)	0.54
	230/138-kV Autotransformer at Canyon Substation (50/66/85 MVA)	0.7
	230/138-kV Autotransformer at Lathrop Wells Substation (100/133/167 MVA	1.4
	Total Alternative E	48.18

Table C-1. Alternatives Relative Cost Comparison Breakdown

Alternative	Major Components	Estimated Cost ($ million)
Alternative F	138-kV line from Northwest Switching Station to Mercury Switching Station	12.2
	Upgrade 138-kV line conductor from Mercury Switching Station to Jackass Flats	1.7
	Upgrade 138-kV line conductor from Jackass Flats Substation to Canyon Substation	0.8
	138-kV line from Canyon Substation to the YMP	1.1
	138-kV line from Lathrop Wells Substation to the YMP	3.4
	138-kV North West Switching Station (1 terminal)	0.5
	138-kV Mercury Switching Station (1 terminal)	0.5
	138-kV Addition to Canyon Substation (1 terminal)	0.5
	YMP 138-kV Switchyard (3 terminals)	2.2
	138-kV Lathrop Wells Substation (1 terminal)	0.5
	Total Alternative F	23.4
Alternative G	230-kV line from Anaconda Substation to Lathrop Wells Substation	33.2
	230-kV switchyard at Anaconda Substation (1 terminal)	0.6
	230-kV switchyard at Lathrop Wells Substation (2 terminals)	1.6
	Subtotal from Alternative D	50.7
	Total Alternative G	86.1

Table C-2. Transmission Line Relative Cost Comparison

Transmission Line	Approximate Length (miles)	Cost at 138 kV ($146,000/mile)	Cost with 20% Contingency	Cost at 230 kV ($173,000/mile)	Cost with 20% Contingency
Pahrump Substation to Lathrop Wells Substation	50	$7.3 million	$8.7 million	$8.65 million	$10.4 million
North West Switching Station to Mercury Switching Station	70	$10.2 million	$12.2 million	$12.1 million	$14.5 million
Lathrop Wells Substation to YMP	19	$2.8 million	$3.4 million	$3.3 million	$4.0 million
YMP to Canyon Substation	6	$0.88 million	$1.1 million	$1.0 million	$1.2 million
Canyon Substation to Jackass Flats Substation	9	$1.3 million*	$1.6 million*	$1.6 million	$1.9 million
Jackass Flats Substation to Mercury Switching Station	20	$2.9 million*	$3.5 million*	$3.5 million	$4.2 million
Anaconda Substation to Lathrop Wells Substation	160 +5/-20	$23.4 million	$28.1 million	$27.7 million	$33.2 million

*For this existing line, it is more likely that the conductor will be upgraded.

Table C-3. Switching Station Relative Cost Comparison

Item	Quantity	138 kV		230 kV	
		Each ($)	Extension ($)	Each ($)	Extension ($)
Gas breakers (installed)	5	177,000	885,000	253,000	1,265,000
Gang switches (installed)	14	26,000	364,000	37,000	518,000
3-pole disconnect switches	10	37,000	370,000	45,000	450,000
Surge arresters (installed)	9	4,700	42,300	6,800	61,200
Current transformers (installed)	15	14,000	210,000	17,000	255,000
Potential transformers (installed)	3	19,000	57,000	23,000	69,000
Subtotal			1,928,300		2,618,200
Bus, structure, grounding, etc., 15% of above	Lot		289,245		392,730
Protective relaying, control, SCADA, etc. (1.5% of above)	Lot		28,925		39,273
Subtotal			2,246,470		3,050,203
Contingency (20%)			449,294		610,041
Total			2,695,763		3,660,244
Number used in estimates			2,700,000		3,700,000

Note: Use 20 percent of above totals for single-breaker terminal. Add 20 percent for each additional terminal desired.

The estimated autotransformer costs, which are not included in the estimate in Table C-3, are shown in Table C-4.

Table C-4. Estimated Autotransformer Costs

Autotransformer	Cost per MVA ($)	Unit Cost ($)	20% Contingency ($)	Total ($)
138/230-kV Autotransformer, 50//67/85 MVA	12,000	600,000	120,000	720,000
138/230-kV Autotransformer, 100/133/167 MVA	12,000	1,200,000	240,000	1,440,000

APPENDIX D

CALCULATION OF SOUTH PORTAL SUBSURFACE WATER REQUIREMENTS

APPENDIX D

CALCULATION OF SUBSURFACE WATER REQUIREMENTS

References for Appendix D refer to the references listed in Section 3.7.

D .1 DESIGN INPUTS

D.1.1 DESIGN PARAMETERS

Items D.1.1.1 through D.1.1.7 are similar for both the North and South Portals.

D.1.1.1 The potable water distribution system shall be sized according to the greatest demand. Water velocity shall be minimized to prevent water-hammer or scouring effect. Potable water distribution systems shall be designed to deliver a peak flow 2.5 times the average daily demand, at a minimum residual pressure of 2.11 kilograms per square centimeter (kg/cm^2) at ground elevation (CRWMS M&O 1996, Section 7.2.4.2 IV.A.1).

D.1.1.2 Water mains shall be designed to have a minimum pressure rating of 10.55 kg/cm^2 for normal operating pressure, ranging from 2.81 kg/cm^2 to 7.03 kg/cm^2 in distribution mains and building service lines (CRWMS M&O 1996, Section 7.2.4.2 IV.A.2).

D.1.1.3 Each fire hydrant within the distribution system at the South Portal facilities shall be designed to deliver 3785 liters per minute (L/min) of water at a residual pressure of not less than 0.7 kg/cm^2. Fire hydrant branches (from the main to hydrant) shall be not less than 152 mm in diameter, and no longer than 91 m (m), in accordance with CRWMS M&O 1996, Section 7.2.4.2 IV.4.3.

D.1.1.4 Fire hydrants shall be installed at a maximum spacing of 122 m. Fire hydrants shall be located no more than 91 m from the buildings to be protected. Each building shall be protected by a minimum of two fire hydrants (CRWMS M&O 1996, Section 7.2.4.2.IVA.6).

D.1.1.5 Two independent water systems shall be provided, one for potable water, and a separate system for nonpotable water (CRWMS M&O 1996, Section 7.2.4.2.IV.A.12).

D.1.1.6 The potable water system (shower, lavatory, sink, and drinking water) shall be designed for a maximum daily occupancy of 400 people, with a consumption rate of 189 L per capita per day. A chlorination system shall be provided to treat potable water, as necessary, to meet safe drinking water standards (CRWMS M&O 1996, Section 7.2.4.2.IV.4.10).

D.1.1.7 The elevation of booster pumps and water tanks at Well J-13 is 1,011 m, according to CRWMS M&O 1993a through 1993f and 1995b and c.

D.1.1.8 The length of pipe between Pump Station J-13 and the booster pump station located at the intersection of H Road and North Portal Road is 6,116 m (CRWMS M&O 1993a through 1993f and 1995b and c.

D.1.1.9 The elevation of the booster pump station located at the intersection of H Road and North Portal is 1,131 m above mean sea level (msl) according to CRWMS M&O 1995b.

D.1.1.10 The length of pipe between the booster pump station and water tanks located at the South Portal pad is 2,743 m (CRWMS M&O 1998).

D.1.1.11 The elevation of the South Portal water storage tanks pad is 1,216 m (CRWMS M&O 1998).

D.1.1.12 The elevation of the development shaft collar is 1,452 m, and that of the emplacement shaft collar is 1,455 m (CRWMS M&O 1998).

D.2 SOUTH PORTAL WATER SUPPLY CALCULATIONS

D.2.1 South Portal Surface Facilities Water Requirements

Potable Water Storage Tank Size Calculation

The surface facilities constructed at the South Portal require potable water (domestic water) for the following activities: personnel showers, lavatories, sink, and drinking water. Based on repository development schedule, the workforce task (labor and supervision) was estimated to be 400 people/day. Table D-1 shows the workforce distribution for each phase of work.

Table D-1. Workforce Distribution

Scheduled Phase	Workforce Required	Work Period (Years)	Working Days/Year
Construction	395	5	250
Development	351	21	250
Emplacement personnel will use facilities at the North Portal	95	24	250
Caretaker	97	26	250
Retrieval	138	21	250
Backfill	203	8	250

Table D-1. Workforce Distribution

Scheduled Phase	Workforce Required	Work Period (Years)	Working Days/Year
Closure	145	8	250
Average peak	400		
Source: CRWMS M&O 1997b.			

Individual usage for potable water consumption can be calculated as follows:

Lavatories	57 L/day
Shower	95
Sink	23 L/day
Drinking water	14
Total	189 L/day/person.

Two and a half days of potable water storage is recommended (CRWMS M&O 1996):

- 189 L/person times 400 persons times 2.5 days = 189,000-L (49,930-gallon) tank
- 38 L/person times 300 persons underground times 2.5 days = 28,500-L (7,530-gallon) tank capacity
- Potable water tank capacity = 217,500 L (57,000 gallons)

D.2.2 Industrial Water required at the surface to fabricate the Precast Elements

Inverts required for 7.62-m-diameter mains and ramps:

- 14,410-m excavation length
- 14,410 m/1.22-m invert width = 11,811 units
- 11,811 units times 1.91 m^3 = 22,559 m^3 concrete.

The water required for fabrication is included in cast-in-place concrete and precast elements.

Inverts required for 5.5-m-diameter emplacement drifts:

- 113,863 m (102 drifts) excavation length.
- 113,863 m/1.5-m invert width = 75,909 units
- 75,909 units multiplied by 1.95 m^3 per unit = 148,000 m^3 concrete

The water required for fabrication is included in cast-in-place concrete and precast elements.

Inverts required for 5.5-m-diameter performance confirmation drifts:

- 10,130-m excavation length.
- 10,130 m/1.5 m invert width = 6,753 units.
- 6,753 units times 1.95 m^3 = 13,169 m^3 concrete.
- 13,169 m^3 times 160 L/m^3 = 2,107,000 L total water

Fabrication time is estimated to be 5 years. Water required is 421,408 L/year.

Inverts required for 5.5-m-diameter ventilation/exploration drifts:

- 3,088 m excavation length.
- 3,088 m/1.5 m = 2,059 units
- 2,059 units times 1.95 m^3 = 4,014 m^3 concrete
- 4,014 m^3 times 160 L/m^3 = 642,240 L total water

Fabrication time is estimated to be 5 years. Water required is 128,448 L/year.

5.5-m-diameter emplacement drifts precast lining.
113,863 m excavated length
113,863 m/1.5 m ring width = 75,909 rings. (Only 16,906 rings are considered for fabrication, because the difference of water is included in cast in place concrete and precast elements.)
16,906 rings times 3.83 m^3 /ring = 64,752 m^3 concrete
64,752 m^3 times 160 L/m^3 = 10,360,000 L.
These units can be fabricated on 15-year period versus 21-year excavation period.
Water required = 690,688 L/year.

Cast-in-place concrete, including inverts and drift liners:

- (1) for Construction period 216,400 m^3 of concrete times 160 L/m^3 = 34,624,000 L water/5-year fabrication period = 6,925,000 L/year water.
- (2) for Development period 432,539 m^3 of concrete times 160 L/m^3 water = 69,206,000 L/21-year fabrication period = 3,296,000 L/year

Additional water required for concrete curing, steaming, etc.:

- For a period of 15 years, 225,000,000 L of water has been estimated. Water required is 15,000,000 L/year.

Additional water required for dust suppression at the surface facilities:

- For a period of 26 years, 390,000,000 L of water has been estimated. Water required is 15,000,000 L/year.

Additional water required for washing concrete cars, and underground equipment before repairs:

- For a period of 23 years, 216,000,000 L of water consumption has been estimated.
- For first period of 1.6 years (cast in place for main entries) the water consumption will be higher, at 50,000,000 L/year.
- After that, for a period of 21 years, water consumption will drop to 6,476,000 L/year.

Total Industrial Water Consumption for the Surface Facilities (peak consumption) is 87,717,000 L/year (23,175,000 gallons).

D.2.3 Fire Protection for the Surface Facilities - Water Tank Capacity

The size of the fire protection tank shall be based on the need to extinguish an assumed fire to the largest building constructed on the pad. In our case, the warehouse dimensions are 100 m by 40 m, or 4,000 m^2. This building can store class III storage materials, with the possibility of stacking items 5 m high, using 2.4-m aisles and double-row racks. Using 286-degree sprinkler heads with a density of 1.66 L/m^2, based on NFPA 231C, Paragraphs 5 through 10, the water supply duration in case of fire must be a minimum of 120 minutes. DOE Order 6430.1.A, Section 1530-3.3.2, requires a minimum hose stream volume of 1,893 L/min.

4,000 m^2 times 1.66 L/m^2 = 6,640 L/min.
10% hydraulic increase factor = 7,304 L/min.
House stream allowance = 1,893 L/min.
Maximum demand on this case: 1,893 L/min. + 7,304 L/min. = 9,200 L/min (2,431 gpm).
NFPA 231C requires 120 minutes of water for Type I, II, and III commodities; the tank capacity becomes 9,200 L/min times 120 min = 1,104,000 L/day.

In addition to the above amount, industrial water for surface and underground usage must be added, as follows (CRWMS M&O 1996):

- 268,427,000 L/year is total industrial water peak consumption.
- 268,427,000 L/year/250 days/year working days = 1,074,000 L/day.
- The industrial water tank capacity is:
  - 1,104,000 L/day + 1,074,000 L/day = 2,178,000 L (575,000 gallons)
  - 3 Tanks times 732,000 L/tank (200,000 gallons each) are required to be installed

D.2.4 Industrial and Potable Water for Underground Activities

D.2.4.1 Cast in Place Concrete and Precast Elements for the Mains and Turnouts

Cast-in-place concrete, as a permanent support, will be applied to all 7.62-m-diameter tunnels and turnouts. Because in the construction phase turnout floors were excavated higher than the main floor to satisfy 5.5-m-diameter TBM requirements, the floor for the east and west mains must be elevated with cast-in-place concrete.

The cast-in-place operation will be carried out on a three shifts/day operation and will include:

1. Washing the walls and floor with water
2. Installing the concrete forms
3. Pouring concrete
4. Disassembling forms
5. Spraying the concrete with water for the curing process.

The quantities of water and the repository development phases are summarized in Table D-2.

Table D-2. Water Quantities and Repository Development Phases

Development Phase	Years Duration	Total Water Quantity (Thousand L)	Total Water Quantity. (Thousand L/year)	Peak Water Supply, based on L/year Water consumption (Thousand L)
1. Water for cast-in-place in mains and turnouts, and partial precast elements, water for washing walls.				
Construction	5	37,373	7,475	7,475
Development	21	79,566	3,789	4,058 (Including the water for 9,600 m emplacement drifts excavated early)
Emplacement	24	176	7	-
Closure	7	304	43	-
Additional water for cast-in-place curing process.	5	30,000	6,000	6,000
Water for washing walls.	1.6 and 21	88,574 for mains cast in place and 109,944 for turnouts.	55,359 and 5,235	55,359 (the largest number is considered)
Total		315,937	77,908	72,892 (19,258 gallons)

D.2.5 TBM Excavation

It is assumed that water use for the 7.62 m and 5.5-m-diameter TBMs is roughly equivalent. ESF tunnel excavation records show that 6,003,000 L of water were used to excavate 905 m of drift. Based on this data, 6,633 L/m of water has been considered for TBM cooling and dust suppression at the face. The total amount of water for the development phases is summarized in Table D-3.

Table D-3. Total Water Use

Development Phase	Total Excavation (m)	Total Excavation (years)	Total Water Required (Thousand L)	Peak Water Supply, based on L/year water consumption (Thousand L)
Construction	17,498	5	116,064	23,213
Development	123,993	21	822,446	39,164
Total			938,510	39,164 (10,347 gallons per year)
Source: CRWMS M&O 1997a.				

If excavation rates are increased and as many as four TBMs are needed, the contingency would absorb the increase in water usage.

D.2.6 Other Excavation Equipment

Secondary excavation equipment required for repository construction and development activities include roadheaders, raise borers, and shaft reamers. Water consumption can be calculated as follows:

Two roadheaders are planned for excavating access cross-cuts, assembly/disassembly chambers, alcoves, and turnouts. The active cutting time for this equipment is assumed at 3 hours per shift or 9 hours/day. The water consumption at the face (motor and bit cooling and dust spray) is assumed to be 3,407 L/hour (15 gpm). This also includes water for rockbolting equipment. Accordingly (Tamrock Voest Alpine Company):

- 3,407 L/hour times two machines times 9 hours/day = 61,326 L/day
- 250 days/year times 61,326 L/day = 15,332,000 L/year

Because the roadheaders will work in tandem with two rockbolters, these are also are included in the schedule.

One raise borer (2.0 m diameter) will excavate the ventilation raises between the emplacement drift and performance confirmation drifts and the exhaust main. The same equipment will be used to excavate the muck transfer raises in the center of the development and emplacement shafts. According to manufacturer information (Robbins Company), 3,677 L/hour of water will be required for cooling and dust suppression.

The time to excavate one vent raise is 9 days/unit. 135 vent raises times 9 days/unit = 1,215 days.
1,500 hours/year active time times 4.86 years = 7,290 hours.
7,290 hours times 3,677 L/hour = 26,805,000 L is total water required to excavate the ventilation raises.
26,805,000/10 years active time = 2,681,000 L/year.
510 hours times 3,677 L/hour = 1,875,000 L is total water required to excavate the muck transfer raises in both shafts.
The peak water consumption considered is 2,681,000 L/year.

One down shaft reamer is required to enlarge the shaft excavation from 2.0 m diameter to the 6.7-m-diameter final outer dimension
342 m is the development shaft excavation depth. Down reaming time for this activity is 131 days or 1179 hours (9 hours active time/day).
The water consumption recommended by the manufacturer is 6,500 L/m.
342 m times 6,500 L/m = 2,223,000 L.

417 m is the emplacement shaft excavation depth. Down reaming excavation time for this activity is 160 days or 1,440 hours.
417 m times 6,500 L/m = 2,711,000 L.

8,000 m^3 concrete will be required for the shaft linings.
8,000 m^3 times 122.5 L/m^3 = 1,000,000 L.
Peak water consumption considered for this case is 1,000,000 L/year.

D.2.7 Additional Water Required for Underground Dust Suppression

This water is required to suppress dust on the main conveyor, the TBM conveyors, muck transfer points, side dump cars at unloading stations, and water mist curtains behind the roadheader excavations.

For a period of 26 years for construction and development, 228,309,000 L of water are estimated to be consumed. Peak water consumption is estimated to be 9,166,000 L/year. From this amount, approximately 7,055,000 L/year will be used for the transfer points and muck dump stations, 1,361,000 L/year to spray the belt conveyors, and 750,000 L/year for the water mist curtains and dust scrubbers.

D.2.8 Underground Potable Water Requirements

The peak workforce is estimated at 400 people/day (labor and supervision) for repository development. From this number, 100 people will be working on surface as support personnel.

At 38 L/day/person drinking water consumption, the total water required per year is 300 persons times 38 L/person times 250 days/year = 2,850,000 L/year peak water consumption, or 74,100,000 L for 26-year period.

To facilitate access of potable water close to the working faces, a 100-mm potable water pipe can be installed in the South Ramp between the surface potable water chlorination station and Station 64+25.206 m where the First Aid and Lunch Rooms will be located.

Table D-4 shows the total water consumption at the South Portal surface and underground required to develop the repository.

Table D-4. Total Water Consumption at the South Portal

Activity	Total Water Quantity (Thousand L)	Total Water Quantity (Thousand L/year)	Peak Water Supply, based on L/year water consumption (Thousand L)	Phase Years Duration
1. Water use for Cast in Place Concrete and Partial Precast Elements in Mains, Drifts & Turnouts.				
Construction	37,373	7,475	7,475	5
Development	79,566	3,789	4,058 (including the water for 9600 m emplacement drifts excavated early)	21
Emplacement	176	7	-	24
Closure	304	43	-	7
Additional water for concrete curing underground	30,000	6,000	6,000	5

Table D-4. Total Water Consumption at the South Portal

Activity	Total Water Quantity (Thousand L)	Total Water Quantity (Thousand L/year)	Peak Water Supply, based on L/year water consumption (Thousand L)	Phase Years Duration
Water to wash the drifts walls and floors before placing cast in place lining, and for mapping. Water recovery approximately 11%	88,574 quantity required for Mains cast in place, and 109,944 quantity required for turnouts and walls mapping. Water recovery approx. (36,611)	55,359 and 5,235	55,359 (as maximum quantity of water)	23
Total	345,937	77,908	72,892	
2. Water use by the TBMs				
Construction	116,064	23,213	-	5
Development	822,446	39,164	39,164	21
Total	938,510	62,377	39,164	
3. Water use by Other Mining Equipment.				
Roadheader and rockbolting equip.	398,632	15,332	15,332	26
Raise borer	26,810	2,681	2,681	10
Down shaft reamer	5,422	2,711	2,711	2
Total	430,864	20,724	20,724	
4. Additional water for dust suppression at the muck transfer points, belt conveyor spray, and water mist curtains.	183,417 use for transfer points, 19,500 use for mist curtains and 25,392 use for belt conveyor	7054 + 750 + 1,361	9,165	26

Table D-4. Total Water Consumption at the South Portal

Activity	Total Water Quantity (Thousand L)	Total Water Quantity (Thousand L/year)	Peak Water Supply, based on L/year water consumption (Thousand L)	Phase Years Duration
Total	238,309	9,165	9,165	
5. Potable water for underground personnel	74,100	2,850	2,850	26
Total	74,100	2,850	2,850	
6. Fabrication Water for Precast Elements				
Inverts for construction phase	2,749	550	-	5
Lining for emplacement drifts	10,360	691	691	15
Additional water for concrete curing, and steaming at surface	225,000	15,000	15,000	15
Additional water for dust suppression at the surface facilities, and access road to the collar shafts	390,000	15,000 (water for surface facilities = 9,000; for access road to the shafts collar = 6,000)	15,000	26
Additional water for washing the concrete cars, and equipment before are repaired. Water recovery is estimated at 25%	80,000 for cars serving Mains cast in place, 100,000 for cars serving turnouts, and 36,000 washing other equip. Water recovery = 211,000	50,000 + 4,762 + 1,714	50,000	1.6; 21; 21 years.

Table D-4. Total Water Consumption at the South Portal

Activity	Total Water Quantity (Thousand L)	Total Water Quantity (Thousand L/year)	Peak Water Supply, based on L/year water consumption (Thousand L)	Phase Years Duration
Total	844,109	87,717	80,691	
7. Potable Water for South Portal Surface Facilities				
Construction	93,319	18,664	18,664	5
Development	348,280	16,585	16,585	21
Emplacement	-	-	Use the facilities at the North Portal.	24
Caretaker	119,165	4,583	-	26
Retrieval	136,931	6,521	-	21
Backfill	76,734	9,592	-	8
Closure	54,810	6,851	-	8
Total	829,239	62,796	35,249	
8. Water for unknown situations	200,000	7,692 (additional alcoves, or silica particles suppression)	7,692	26
Subtotal	3,901,000	331,229	268,427	
Water recovered	248,000	9,538		
Total water peak	3,653,000	321,691	268,427 liters or 71,000 gallons	